JOURNAL of the

SOCIETY of MOTION PICTURE and TELEVISION ENGINEERS

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68th Semiannual Convention • Oct. 16–20 • Lake Placid

SEPTEMBER 1950

Bill Kunzmann invites you, your family and friends to attend the

68th Semiannual Convention
Lake Placid Club
October 16–20, 1950

As Convention Vice-President, Bill will be your host at this first convention in many years to be held away from a big city. Reservation cards went out in mid-August, and Tentative Programs listing all papers were mailed just after Labor Day. If yours did not arrive or you need extra copies, write Society Headquarters at once and you will get them by return mail.

Ten Technical Sessions have been scheduled to accommodate a fine program of papers arranged by the Papers Committee.

Highlighting the nontechnical activities will be: on Monday evening, presentation of awards and a poignant address by a prominent figure in motion pictures; on Wednesday evening, a cocktail party, banquet and dance scheduled as a midweek interlude of fun and frolic. In-between times can be spent in restful relaxation or recreation, since all facilities of the Club will be at your disposal. They include golf, tennis, saddle horses and many other activities.

(Continued on the inside back cover)

JOURNAL READERS:

Supplementing earlier information in the *Journal,* you are reminded to reserve your room for the 68th Convention, to be held October 16–20 at the Lake Placid Club, Lake Placid, N. Y.

Special rates at the Lake Placid Club are American Plan and therefore cover all *meals, including the Wednesday evening Banquet, and* all *gratuities for the week. There will be no additional tips or charges of any kind beyond the convention registration fee of ten dollars. For ladies there will be no registration fee.*

Write Donald Nelson, Reservations Manager at the Club, for your accommodations.

RATES—American Plan (Meals Included)

Single Room....................$17.50 per day

Double Room with Twin Beds.....$15.25 per day per person. (When three people occupy one room, the third person pays $9.50 a day; children 6 to 12 years, $7.00 a day; under 6 years, $4.00 a day.)

For further details, check again the references in this and in the July and August *Journals.*

Your attention is invited to a change in one session as it appeared in the Tentative Program. Because conclusive results of current perforation studies have not materialized in time, the Symposium on Film Registration has been replaced by three items now listed for Thursday afternoon. The status of work on film registration will however be covered by Dr. Carver's report.

E. I. SPONABLE, *President*
Society of Motion Picture
and Television Engineers

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Society of Motion Picture and Television Engineers

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New Television Camera Tubes And Some Applications Outside the Broadcasting Field

By V. K. Zworykin

RCA Laboratories Div., Radio Corporation of America, Princeton, N.J.

SUMMARY: The operation and performance characteristics of television camera tubes from the iconoscope to the image orthicon and vidicon are described briefly, stressing recent developments. The application of the vidicon in industrial television equipment and, in greater detail, possible uses of television techniques in astronomy are outlined.

The description of the television camera as an electric eye is as old as television itself. The reason for this is obvious, in view of the function of the television camera. Yet, to anyone viewing the images produced by early television systems, the term may well have seemed presumptuous and the comparison with the human eye remote.

The human eye is indeed a marvelous mechanism. It functions efficiently over a brightness range of one to one-hundred million, 10^{-6} foot-Lamberts to 10^{2} foot-Lamberts. At low light levels quanta incident over a cone with a vertex angle of 30 min co-operate to produce a single visual sensation, while at high light levels visual angles as small as one minute are resolved. With a quantum efficiency of the order of 5% at low light levels, the contrast recognition of the eye is limited only by the statistical fluctuation in the incidence of the light quanta. This is given simply by the square root of the total number of quanta imaging a "picture element" of the object on the retina within the storage period of the eye, approximately a fifth of a second. It has been found experimentally that the recognition of brightness contrast between two picture elements of equal size requires that their average brightness difference should exceed the statistical fluctuation in brightness at least by a factor of 5. If, for instance, 1000 quanta on the average are absorbed in a particular picture element projected on the retina within the storage period of a fifth of a second, the statistical fluctuation will be 30 quanta or 3% of the element brightness; thus, in order that an element of equal size be distinguishable from the first element, it must

Presented: October 13, 1949, at the SMPE Convention in Hollywood.

differ from it by 15% in brightness. This is the threshold contrast under the conditions here described. It is seen that, in general, the threshold contrast is inversely proportional to the square root of the brightness and the picture element area.

The same principles which govern the contrast recognition and sensitivity of the eye apply to any other light-sensitive devices, such as television camera tubes. The fact that photosensitive surfaces with quantum efficiencies of 5% and better are available suggests that, ultimately, pickup devices with sensitivity equal to that of the human eye can be achieved. Today this goal has in fact been attained, at least within limited ranges of operation. A brief outline

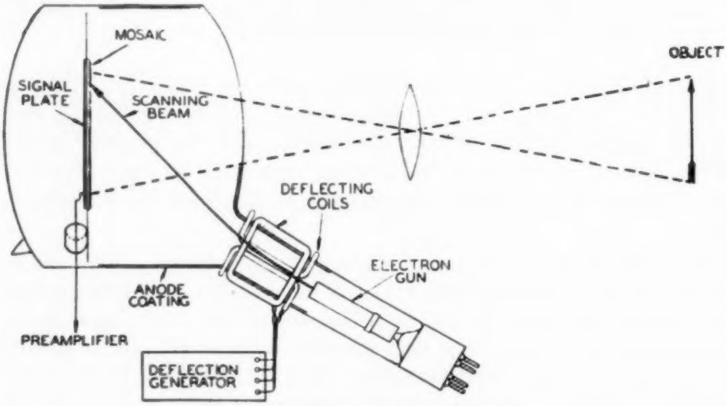

Fig. 1. Diagram of the iconoscope.

of the development will indicate the nature of the obstacles which had to be overcome and show where further progress may be expected in the future.

The first television camera tube which shows a close correspondence with the properties of the eye, the iconoscope, was conceived some 26 years ago.

In detail, the iconoscope (Fig. 1) functions in the following manner: The picture is projected on a mosaic of minute sensitized silver globules deposited on a mica plate. Under the influence of illumination these globules give off photoelectrons and are charged positively; the change in potential is determined both by the charge lost and the capacity of the element relative to a metal film on the back of the mica, the signal plate.

The surface of the mosaic is scanned in a regular line pattern—

525 lines every thirtieth of a second—by a sharply focused electron beam. The beam restores the original electrical potential wherever it strikes the mosaic. In doing so it releases from the signal plate a charge equal to the charge stored in the scanned element and this released charge applies a voltage pulse proportional to the stored photoelectric charge to the picture amplifier. The succession of these voltage pulses constitutes the video signal. Applied to the grid of a viewing tube, whose fluorescent screen is scanned in unison with the iconoscope mosaic, it reconstructs on the viewing screen the image projected on the mosaic.

A vital property which the iconoscope shares with the human eye and which was absent from all earlier television systems is storage. The video signal of the iconoscope is determined not only by the photoelectric charge released by the light at the instant of scanning, as in nonstorage systems, but by the charge stored by the light in the picture element considered throughout the period between successive scannings. Thus storage permits an increase in sensitivity by a factor equal to the total number of picture elements.

This gain is not realized in full in the iconoscope. The field conditions in front of the mosaic prevent efficient storage of charge and efficient utilization of stored charge for the formation of the video signal. These and other secondary factors combine to make the sensitivity of the iconoscope less than that of the eye by 3 to 4 orders of magnitude at low light levels.

In the iconoscope the scanning beam consists of 1000-v electrons which, at incidence on the mosaic, eject a considerable number of secondary electrons for every incident beam electron. The "redistributed" secondary electrons give rise to a spurious signal or "shading," which may require manual compensation by the monitoring engineer. The weak retarding field in front of the mosaic also serves to return to the emitting element, or to redistribute, a large fraction of the photoelectrons, impairing the efficiency of charge storage. Under normal operating conditions these causes reduce the video signal amplitude to about 5% of the value attainable with ideal collection.

It should be noted that the same factors which lead to relative inefficiency and the presence of shading also have some desirable consequences. These are perfect stability at all levels of illumination and a nonlinearity of response which compensates the nonlinearity of opposite sign of the viewing tube.

The first successful improvement on the iconoscope consisted in projecting the light image on a continuous transparent photocathode

and employing the photoelectrons so generated to form an electron image on the mosaic. The charges stored in this manner on the mosaic, and hence the output signal, were greater than in the ordinary iconoscope for two reasons: The continuous photocathode was more photosensitive than the mosaic and five or more secondary electrons left the mosaic for every primary photoelectron incident on it. The

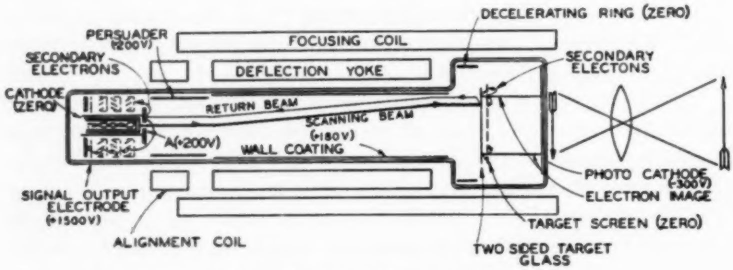

Fig. 2. Diagram of image orthicon.

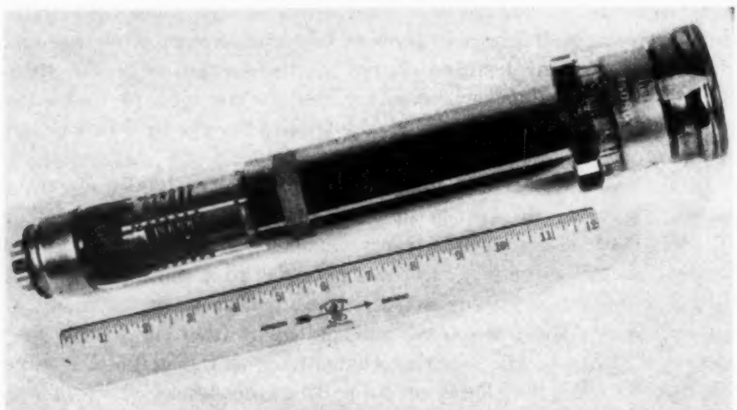

Fig. 3. Image orthicon.

"image iconoscope," formed in this manner was, in fact, up to ten times more sensitive than the ordinary iconoscope. Modern versions of it are employed today, with considerable success, in France.

The image iconoscope increased the signal level and hence the sensitivity of the pickup tube, but left the unfavorable field conditions in front of the mosaic essentially unaltered. The orthicon on the other hand is distinguished by the presence of a strong collecting

field in front of the mosaic which guarantees complete collection of photoelectrons and secondary electrons and prevents the occurrence of spurious shading signals. This occurs when the surface is approximately at cathode potential.

The difficult problem which had to be solved before the orthicon became practical consisted in attaining a very small spot size at low electron velocities and retaining this, as well as the perpendicular direction of incidence of the beam on the mosaic, for all deflections. The problem was finally solved by immersing the tube in a longitudinal magnetic focusing field and superposing horizontal and vertical magnetic deflecting fields on it. The secondary electrons as well as those which are turned back in front of the mosaic follow very nearly the same paths as the incident beam and are ultimately collected by a diaphragm in front of the cathode. This method of focusing has proved so successful that better than thousand-line resolution has been achieved with it on a mosaic approximately two inches in height.

The performance of the orthicon is as expected. There is a complete absence of shading signals and a strictly linear relation between signal and light—up to a certain limit. Its sensitivity is approximately an order of magnitude greater than that of the iconoscope. It has given good service and in modified form is finding wide employment in England today.

The perfect stability of the iconoscope, the highly sensitive continuous photocathode of the image iconoscope, the freedom from shading of the image orthicon, and a high level of signal output made possible by secondary emission multiplication were finally combined in the image orthicon, developed in the middle forties. This ingenious tube is represented schematically in Fig. 2. The two-sided target, which takes the place of the mosaic, consists here of a very thin film of glass, whose conductivity is high enough so that differences of potential on its two opposite faces are largely wiped out by conduction in the course of a frame time. Yet the film is so thin that charge leakage from one picture element to its neighbors, within the same period, is negligible. To the right of the target is the image section of the tube. Photoelectrons ejected from the photocathode by the light image of the scene to be transmitted are focused magnetically on the glass target. Here they eject secondary electrons, which are either collected by a very fine-meshed target screen in front of the target or turned back to the target.

To the left of the target is the scanning section of the tube, which in most details resembles that of the orthicon already described.

However, the signal is carried by the return beam, from which a number of electrons equal to those removed from the target by secondary emission are abstracted. The return beam is incident on a diaphragm surrounding the scanning beam and ejects from it secondary electrons which spill over into an array of secondary emission sensitized pinwheels surrounding the cathode. These pinwheels function as stages of a secondary emission multiplier which amplifies the return beam by a factor of 300 to 1000. In the picture of the image orthicon (Fig. 3) the pinwheels are visible near the base of the tube.

The variation of the signal strength with illumination on the photocathode is shown for three image orthicons in the next figure

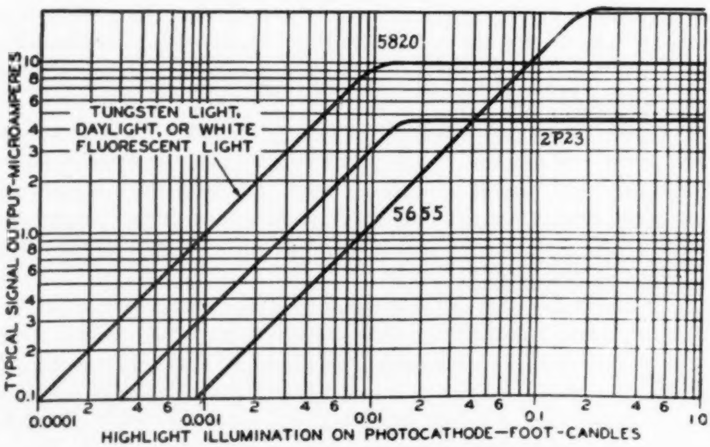

Fig. 4. Response characteristics of three image orthicons.

(Fig. 4). As long as the target potential remains below that of the target screen, the collection of the secondary electrons is virtually complete and the response perfectly linear, as indicated by the first part of the two curves. On the other hand, for higher intensities of illumination the response rapidly levels off and soon ceases to increase with further increase in illumination. Redistribution of electrons at the boundaries between regions corresponding to different illuminations then serves to establish edge contrasts which result in a fairly natural rendition of the scene.

It has been shown by Dr. Rose of the RCA Laboratories that the performance of any pickup device can be adequately described

in terms of the brightness, contrast and angular dimensions of detail of the object that can be perceived with the device employing a lens of given aperture and a given storage time. These several factors combine to yield a performance figure which, for an ideal system, becomes equal to the quantum efficiency of the primary photoprocess taking place in the device. Figure 5 shows the performance parameter as function of scene brightness for the human eye, motion picture film and several television pickup tubes. As might have been expected, no man-made device approaches the human eye in its

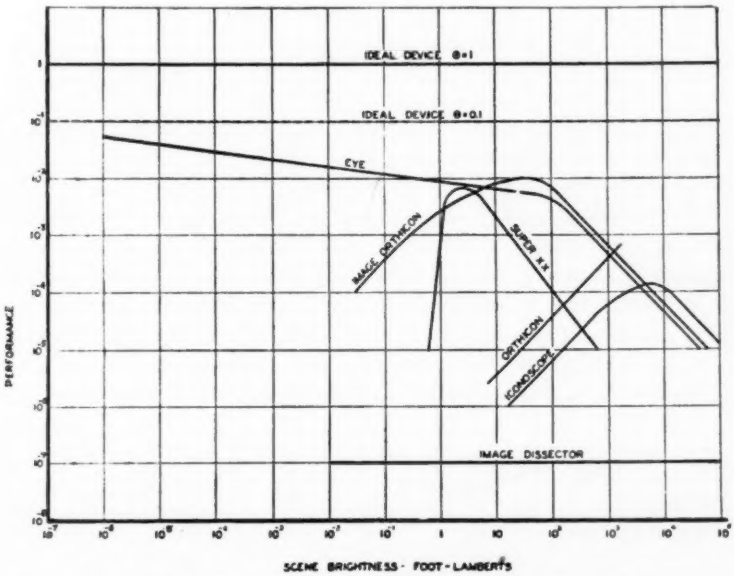

Fig. 5. Figure of merit of human eye, motion picture film and television pickup tubes as function of scene brightness (A. Rose).

range of satisfactory performance. Among man-made devices, on the other hand, the great superiority of the image orthicon at low light levels is clearly evident. It is seen, in fact, that the image orthicon has within a considerable range a performance figure of the order of 1%, that is nearly equal to the quantum efficiency of its photocathode; hence in this range it can justly be regarded as an ideal device.

It would be mistaken, however, to consider the image orthicon as an endpoint in camera tube development. Apart from the obvious goal of greater sensitivity of the photocathode and extension of the

range to still lower light levels, there is the challenge of simplifying the tube and its auxiliary equipment. It is clear that a tube of the complexity of the image orthicon presents many difficult production problems. In addition, added power supplies are needed for the secondary emission multiplier and the image section and the correspondingly large number of controls complicate the adjustment and servicing of the image orthicon camera.

A considerable advance in the properties of the photocathode has been achieved by substituting for the red-sensitive silver-cesium oxide (2P23, Fig. 6) and the blue-sensitive antimony-silver cesium surfaces

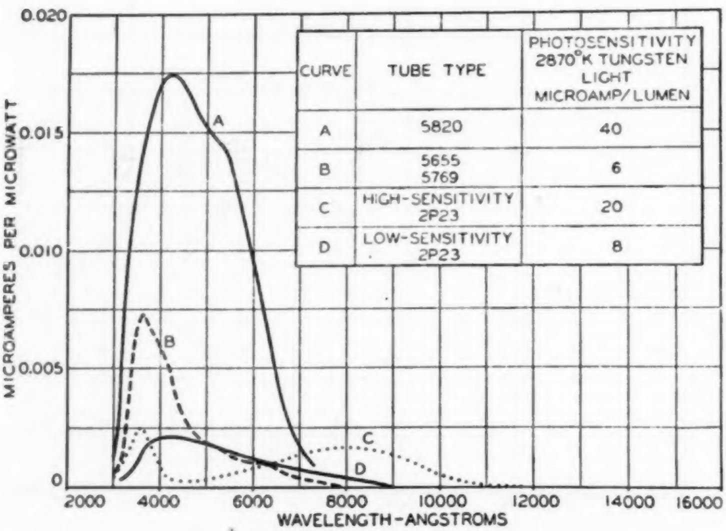

Fig. 6. Spectral sensitivities of different types of image-orthicon photocathodes.

(5655 and 5769, Fig. 6) a new type of bismuth-silver cesium surface (5820, Fig. 6). This not only doubles or triples the sensitivity of the earlier tubes, but greatly improves the match to the color sensitivity of the eye, leading to a more faithful and pleasing reproduction of the transmitted picture. The curves in Fig. 6 show the relative spectral sensitivites of the three types of photosensitive surfaces.

A great simplification in the pickup tube construction and the auxiliary equipment, without corresponding loss in sensitivity, has recently been attained in a new type of pickup tube, the vidicon.

Through the provision of a suitable photoconductive target deposited on a transparent signal plate, the intrinsic sensitivity of the

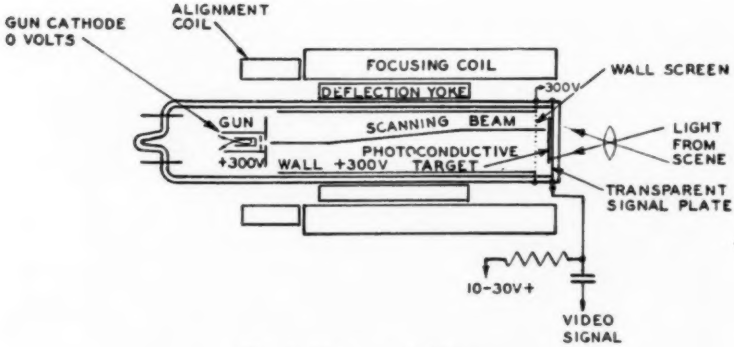

Fig. 7. Diagram of vidicon.

tube has here been raised to such a level that it has become permissible to dispense with the image section and secondary-emission multiplier. Low-velocity scanning is employed as in the orthicon and image orthicon: Light-induced conduction causes, in view of the positive bias on the signal plate, illuminated portions of the target to become positive. The positive charge so stored is neutralized by the scanning beam, giving rise to picture signal pulses in the signal plate lead (Fig. 7).

The small dimensions of the vidicon (Fig. 8)—it is only 1 in. in diameter—fit it ideally for industrial television purposes, where

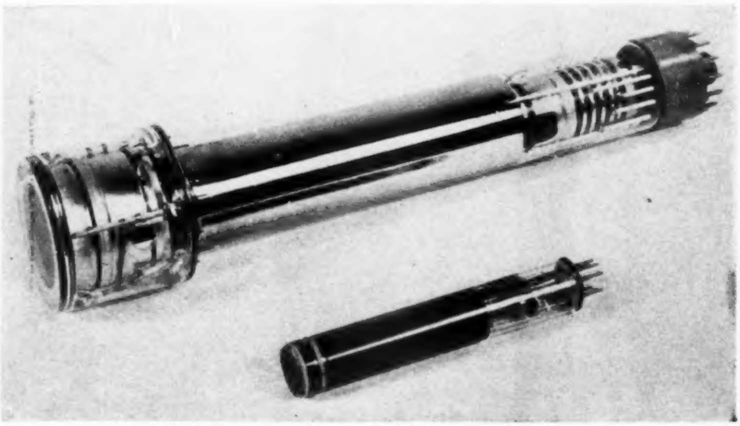

Fig. 8. Comparison of vidicon and image orthicon

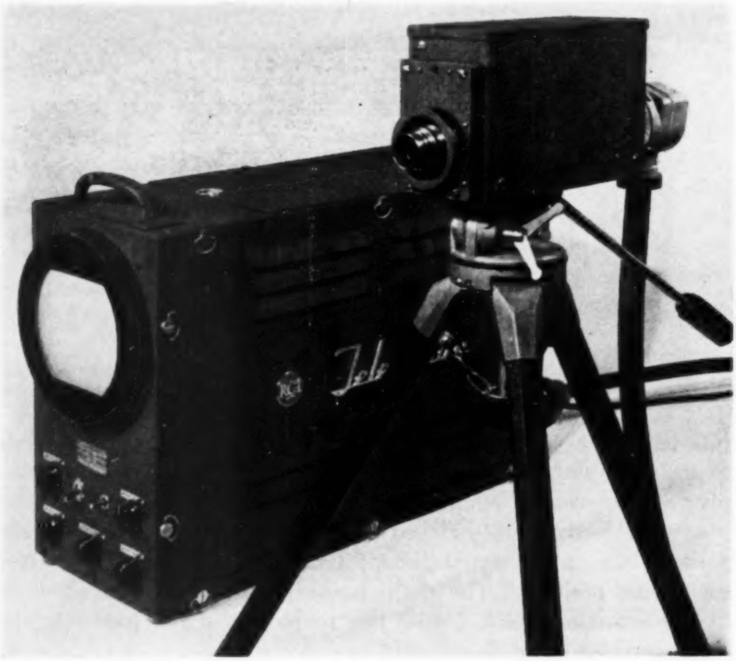

Fig. 9. Industrial television system incorporating vidicon camera.

Fig. 10. Stereo television camera with control unit and monitor.

compactness and portability are decisive advantages. Figure 9 shows a vidicon camera weighing only 8½ lb, together with a complete monitor control unit weighing some 50 lb. In practice, the control unit may be located 500 ft from the camera, being connected to it by cable. Equipment of this type has found many applications in industry, for surveillance and research, and in education, for the demonstration of microslides and surgical operations. For the latter purpose the three-dimensional representation yielded by a stereoscopic television camera (Fig. 10) proves particularly valuable.

The great sensitivity of the newer tubes which have just been described makes them eminently suitable for the transmission of pictures in natural color. High sensitivity is here needed, since the process of separating out the primary component colors of the picture invariably leads to a considerable loss of intensity. One system of color transmission which possesses the advantage of being readily

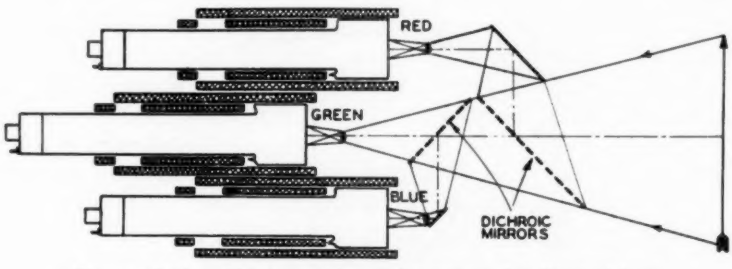

Fig. 11. Optics of image orthicon color camera for direct pickup.

fitted into the existing system of black-and-white broadcast television records the three primary color pictures on separate pickup tubes. Figure 11 shows schematically the arrangement of an appropriate color pickup camera employing three image orthicons. Dichroic reflectors serve to separate the light from the scene into its primary color components, so that different-color images, of identical size, are formed on the photocathodes of the three tubes.

The primary aim in the development of the devices which we have considered so far has been the creation of tools for a satisfactory broadcast television service. Yet their usefulness, and the usefulness of apparatus which may be readily derived from them, goes far beyond this, as we have already seen in connection with the industrial television camera. In particular in the scientific field television techniques can often be applied to great advantage. It is true that the requirements of science and entertainment are so different, often

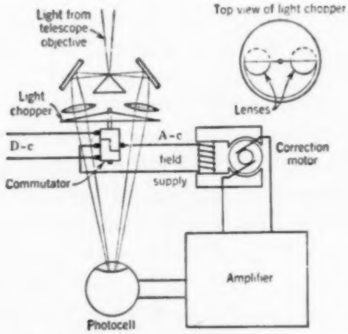

Fig. 12. Photoelectric clock drive Correction (Whitford and Kron).

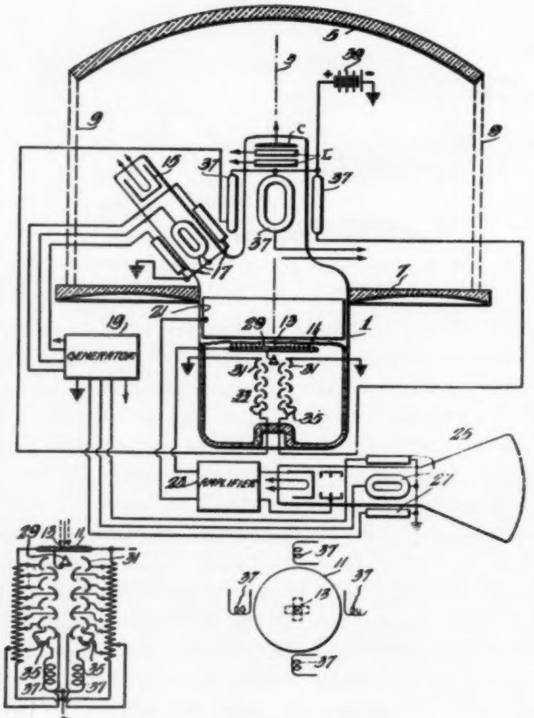

Fig. 13. The Telectroscope.

even diametrically opposed to each other, that our attitudes and methods in the two fields must need be quite different. We shall indicate some ways in which television methods may find application in the field of astronomy.

An obvious use is to let the television camera substitute for the observer at the eyepiece of the telescope, making possible remote control of the instrument with a minimum of thermal and other disturbances. Even if the astronomer himself might not deem it advisable to separate himself to that extent from his telescope, he might readily appreciate the advantages of letting visitors view his equipment and the stars with television eyes instead of with their own.

An electronic technique derived from television development may also be employed to flatten the image field of the Schmidt Camera and, eventually, increase its sensitivity. To this end the curved cathode of an image tube is made to coincide with the focal surface of the Schmidt Camera. This photocathode is imaged electronically on a flat fluorescent screen. In order to photograph the sidereal image, a photographic plate is placed in contact with the screen. Since the number of quanta ejected from the fluorescent screen by each accelerated electron may be made to exceed considerably the average number of quanta required to free a photoelectron from the photocathode, a shorter exposure time will be needed to leave a visible star record on the photographic plate. It is true that, though the image produced at the fluorescent screen is brighter than that at the photocathode, it is also "noisier," that is, contains less intrinsic information.

Television techniques may, furthermore, be employed to advantage for stabilizing star images. Whitford and Kron at Washburn Observatory many years ago installed a photoelectric guiding mechanism on a telescope to correct the clock drive (Fig. 12). A selected fixed star is imaged on the edge of a roof prism, which directs the split beams through opposite sides of a rotating 180° sector disk onto a multiplier phototube. If the intensity of the two beams is unequal an alternating current is generated which is employed to correct the clock drive so that the star image remains centered on the edge of the roof prism. Some time ago the author proposed an all-electronic system with the corresponding almost complete absence of inertia for compensating fluctuations in atmospheric refraction (Fig. 13). In the figure, the sidereal image is formed on the photocathode of an image iconoscope, the electron image of a particular fixed star being centered on a small aperture in the middle of the mosaic. The electrons forming this image fall on the vertex of a

pyramid, whose four sides act as first dynode for four electron multiplier structures. The output currents of the four multipliers pass through four deflecting coils, which serve to maintain the fixed star image centered on the pyramid, so that the sidereal image reproduced on a viewing tube screen appears stationary.

The above method requires the construction of a highly specialized complex electronic centering tube. The same end may, however, be accomplished with the aid of conventional television equipment in conjunction with suitable gating circuits. Figure 14 shows a block diagram of the circuit which may be employed for this purpose.

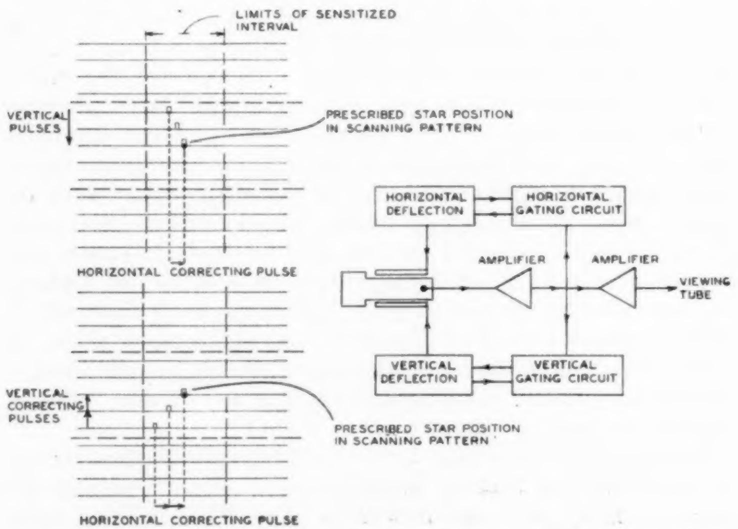

Fig. 14. Electronic image stabilizer for sidereal images.

The sidereal image is projected by the telescope on the photosensitive surface of the pickup tube so that the fixed star serving as "guiding star" is centered on it. Apart from the amplifiers and the television receiver on which the sidereal image is reproduced, centering circuits are provided whose purpose it is to maintain the scanning pattern centered on the guiding star image, independent of atmospheric fluctuations and minor clock errors. Here the output signal of the pickup tube is applied to two gating circuits which are sensitized over a series of time intervals covering a region of a few line widths about the prescribed position of the image of the guiding star in the scanning pattern. If the star image moves slightly in the course of

a frame time, the signal pulse causes the horizontal gating circuit to apply a horizontal centering signal to the tube deflection. The same pulse causes the vertical gating circuit to apply a vertical centering impulse corresponding to the difference in the line number of the actual and prescribed occurrence of the star pulse. To take account of storage, the gating circuits are blanked by the first impulse if, and only if, the latter occurs before the prescribed occurrence of the star pulse.

In speaking of the electronic stabilization of star images to compensate atmospheric disturbances and clock drive errors—a subject discussed last year by Professor Zwicky in Zurich—we have been able to keep our feet on the ground. We shall now contemplate the possibility of placing our telescope in a balloon and ascending to

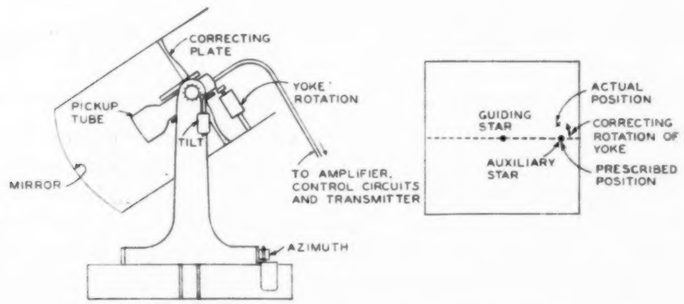

Fig. 15. Image stabilizer for balloon-mounted Schmidt telescope.

heights where atmospheric refraction ceases to play an appreciable role. We will now need electronic methods to maintain the proper orientation of the telescope in spite of the uncontrollable motions of the balloon and, eventually, to send the star images back to earth. Even though this method would not be applicable to the largest telescopes, the possibility of almost completely eliminating atmospheric effects might well render it of value.

We shall again direct our attention to the crucial problem, the stabilization of the sidereal image. As compared with the system for compensating atmospheric fluctuations, we must now count with the possibilities of much greater total displacements and of the rotation of the image. We can take account of the first factor by providing servomotors for the rotation of the telscope about a vertical axis and about a tilt axis (Fig. 15). These servomotors are controlled by the centering currents for the scanning pattern. A third servomotor is

provided to rotate the deflection yoke about the tube axis. This motor is controlled by pulses from an auxiliary guiding star, normally located near the periphery of the scanning pattern, on the horizontal line through the guiding star image. The circuit arrangement for this system is indicated in Fig. 16.

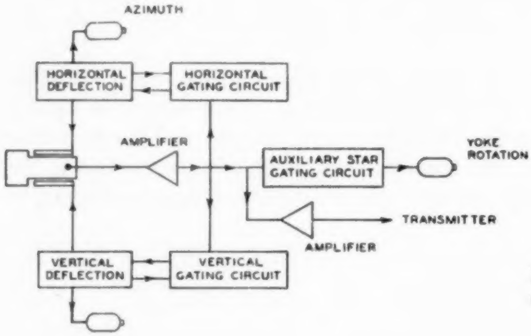

Fig. 16. Block diagram of image stabilizer.

We have mentioned a few ways in which television pickup tubes may perform a service in the field of astronomy. There are without doubt many other ways whose discovery demands familiarity with both the problems of astronomy and the possibilities and limitations of electronic equipment. Experience has shown consistently that material progress in any one field of science and engineering has had a beneficent effect on the development of all other fields. The development of electronic pickup tubes with sensitivities of the same order as that of the human eye should be no exception.

CBS Television Staging And Lighting Practices

By RICHARD S. O'BRIEN

Columbia Broadcasting System, Inc., New York, N.Y.

SUMMARY: Television as a visual medium must be operated within the boundaries of its technical characteristics to achieve good visual reproduction. The system handles a limited range of luminance, introduces luminance transfer distortion, exhibits spurious effects (halos, image orthicon ghosts, clouding, streaking) and has finite detail resolution. It is necessary to provide guidance whereby production personnel can fully exploit the present system.

Accordingly, rules have been formulated for each of the major production operations at CBS, viz., staging, lighting, camera operation and direction. Individuals working in these phases are thus enabled to perform their separate functions with assurance that their combined efforts will produce images which are both technically correct and artistically pleasing.

If television were a perfect visual reproduction medium, it would be possible to allow qualified artistic judgment to be the sole arbiter of staging practices. Television is not, as yet, a perfect transmission system. At the present stage of technical development it is necessary to temper artistry with technicality—to respect rules which recognize the characteristics of the present facilities.

It is an important engineering function to work toward improvement of technical performance. While this work is in progress, it is equally important to study the equipment as it exists and to determine the necessary boundary conditions in order that rational artistic-technical compromises can be made in current program production. The television studio practices which are discussed here have been found helpful in day-to-day operations by the Columbia Broadcasting System.

These practices, concerned principally with the control of scene luminance and content, are outlined in groups of co-ordinated rules for use in the staging (scenery preparation), lighting adjustment and camera operations phases of production. The work of the various production departments, though separated in time and location, is thereby guided to obtain picture quality which avoids known pitfalls and makes the best possible use of the television system.

In this presentation, a review of certain technical characteristics of the present facilities, including illustrations of spurious effects which

Presented: April 25, 1950, at the SMPTE Convention in Chicago.

Fig. 1–A. Halo.

Fig. 1–B. Halo.

Fig. 1. Halo

The heavy black fringe surrounding the young lady in A results from a shower of low-velocity secondary electrons emitted from the high-light areas on the image orthicon target. These electrons land on the surrounding dark area completely discharging the nearby portions. In B, a lighter background has been substituted and the halo has been greatly reduced. In this case, the secondary emission from the background area is now sufficient to alter the field configuration in the vicinity of the target causing the excess high-light area electrons to land properly on the collector mesh.

NOTE: The dashed-line ellipse is a mask placed on the picture monitors to bound the area within which essential picture information should be held to prevent subsequent cropping by receiver masks or the film recording process.

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occur, is followed by the statement and discussion of some of the more important working rules which have been formulated. The intention is to indicate the nature of the approach which has been made toward control of production practices.

TECHNICAL LIMITATIONS OF TELEVISION

Aspects of the *present-day* television facilities which may constitute technical limitations are: total contrast range, shape of the contrast gradient or luminance transfer characteristic, interaction among adjacent picture areas, and detail resolving capability. The characteristics of the image orthicon pickup tubes, of the electrical transmission system and of the reproducing cathode-ray tubes all may contribute to the over-all distortion in picture quality. For a network originating studio, it is particularly important that careful control be exercised as network transmission facilities and television film recordings used for program distribution certainly cannot be expected to minimize picture defects produced in the studio.

Limited total contrast range constitutes one of the most basic problems. The ranges of luminance values which can be handled by several familiar systems are approximately as follows:

The human eye—for a particular luminance adaptation	100 to 1
35-Mm motion pictures—typical projection. . . .	40 to 1
Live, direct-view television—ideal conditions.	40 to 1
Live, direct-view television—typical conditions . . .	20 to 1
Kodachrome-type color film processes	15 to 1

It is important that, in the television scene to be transmitted, all subject matter have a luminance within the approximate 20-to-1 range handled by the system.

Distortion in luminance transfer characteristics may have the effect of increasing the apparent contrast between areas of a scene.

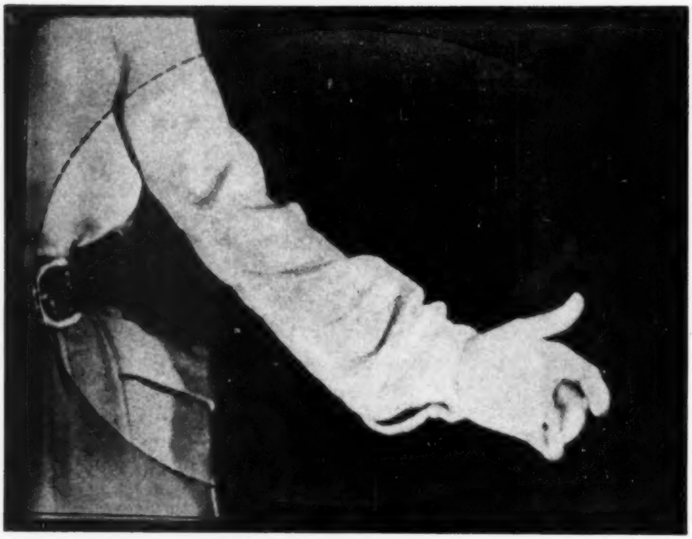

Fig. 2–A. Image orthicon ghost.

Fig. 2–B. Image orthicon ghost.

Fig. 2. Image Orthicon Ghost

The displaced image of the hand shown in A results from high-velocity secondary electrons emitted from the high-light area on the image orthicon target. These electrons travel as a group back toward the photo-cathode, eventually decelerating and returning to the target, producing a positive signal by knocking off secondary electrons as in the case of an ordinary electron image signal. The displacement results from travel through the axial magnetic field present. Here, too, it is possible to minimize the landing of this ghost image by maintaining less contrast between the high-light and the background areas. However, in B, the hand has simply been moved to the center of the raster, where the ghost travels along the axis of the tube and falls back on the high-light area without displacement. Slight defocusing of image focus would also reduce the ghost but at a sacrifice in resolution.

Through a typical direct-view receiver, for example, a 2-to-1 scene brightness difference may under some conditions appear as a 6-to-1 difference due to expansion introduced by curvature of the reproducing cathode-ray tube voltage-to-luminance transfer characteristic. In the studio, the transfer characteristic relating scene luminance to output voltage for the image orthicon tube is similar in shape to the familiar H&D curve for film but is influenced by the level of illumination incident on the image orthicon photo-cathode, by the ratio between high-light and average scene luminance and by adjustment of image orthicon target voltage. It is possible to have compression of one range of luminance values and expansion of another—all in the same scene. This problem again calls for careful control of over-all scene luminance distribution and for careful exposure and camera adjustments.

These troubles are caused in part by the electron redistribution process inherent in present-day operation of the image orthicon pickup tube. Several spurious effects which arise in the tube or associated equipment are even more objectionable at times because of their distinctive appearance. These effects of interaction between adjacent areas include:

Halo: A black area surrounding a bright high-light, resulting from a rain of low-velocity electrons emitted from the high-light area of the image orthicon target and particularly severe on highly polished jewlery, white clothing, and bald heads (see Fig. 1).

Image orthicon ghost: A spurious, displaced image of a high-light area, most noticeable with severe contrast between high-light and background, resulting from high-velocity secondary electrons emitted from the high-light area on the image orthicon target (see Fig. 2).

Clouding: An electronic fogging or mottling of large dark areas, similar in effect to lens flare, particularly severe where excessive contrast exists between large dark and large light areas and aggravated

Fig. 3–A. Clouding.

Fig. 3–B. Clouding.

Fig. 3. Clouding

The inability of the image orthicon to maintain high contrasts over large areas is indicated by the clouding within the silhouette in A. The halo effect serves to maintain a dense black over small areas but beyond its reach, the larger areas are a milky gray, spotted with dynode spots. Note that, although the halo effect holds small area contrasts, it is in the nature of all or nothing, so in other than a silhouette effect, severe distortion in luminance transfer would result. Reduction of the contrast from 35 to 1 to only 5 to 1, shown in B, enables a more uniform black reproduction. This clouding effect will be recognized as being similar to lens flare although it is purely electronic in this illustration.

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by the tendency of multiplier electrode spots to show through in dark areas (see Fig. 3).

Streaking: A dark or light horizontal streak across the picture in line with excessively bright high-lights or long, heavy scenery lines, usually resulting from improper low-frequency characteristics in the transmission system (see Fig. 4).

These effects can be reduced or adequately hidden by the same careful control of staging, lighting and camera operation called for in working within the usable total contrast range and in obtaining good luminance transfer characteristics.

In the matter of detail resolving capability, television falls between 35-mm and 16-mm motion pictures. Good resolution is aided by the same careful staging and lighting called for above, as the camera can then be adjusted to peak performance rather than to a compromise which would accommodate a range of conditions. For example, some of the effects listed under clouding may be hidden by beam defocusing; the image orthicon ghost, by image defocusing; control of staging and lighting makes it unnecessary to throw away resolution to hide such effects.

Studio Practices

As the various spurious effects and the distortion in luminance transfer characteristics are greatly aggravated by overexposure, principal objectives of studio practices must be the maintenance of uniform luminance ranges and scene content throughout a production and the establishment of conditions which are within the capabilities of the television facilities. From the transmission viewpoint only, a very "flat" scene is the easiest to handle. From the equally important artistic standpoint, however, as much contrast as possible is desired to provide scope for artistic expression, simulation of depth and establishment of mood. The technical group must sometimes relax technical quality requirements where special effects are desired momentarily; the staging and direction groups, on the other hand, must

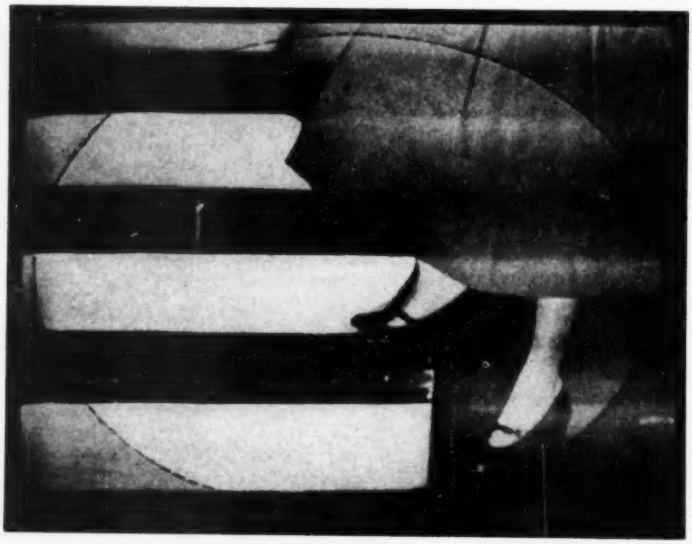

Fig. 4-A. Streaking.

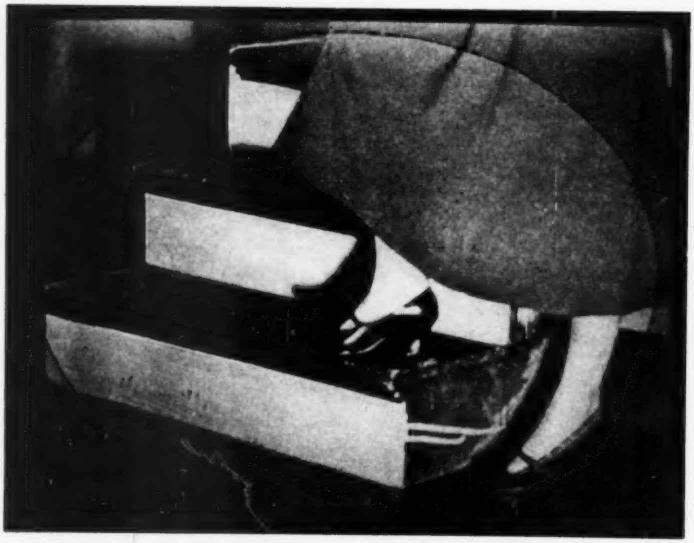

Fig. 4-B. Streaking.

Fig. 4. Streaking

The white stair risers when aligned so as to parallel the television scanning lines produce pulse signals having large energy content on a number of scanning lines. In a video amplifier having improper low-frequency phase or amplitude response characteristics, a transient results, producing a streak across other portions of the picture. The streak may be of either the same or opposite polarity depending on whether leading or lagging low-frequency phase response is involved, for example. In the studio, the contrasts of large horizontal elements may be held down or the length of such elements along the scanning lines may be minimized by turning the element at an angle as in B.

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become accustomed to somewhat more restrictive conditions than are prevalent in motion picture or legitimate stage production. Between the technical and artistic viewpoints lies an area for fundamental compromise, the boundaries of which working rules must seek to establish.

In practical production, the further problem of time and space separation among the various activities must be considered. The scenery may be prepared and costumes selected well ahead of the performance date. Lighting is planned in advance but adjusted after the prefabricated scenery with accompanying properties is set up in the studio. Camera facilities often are activated only during late stages of studio rehearsal. Thus, it is necessary that each major production operation be guided by rules which allow its performance independently but with assurance that the work will fit together as a co-ordinated whole. In the following sections, rules for each production phase are grouped together for convenience in reference with a discussion of the factors involved following each of the groups. Under the subject of staging, which includes scenery preparation, selection of properties, costuming and make-up, the reflectance of materials is controlled. Lighting practices are controlled as to illumination levels and distribution, this being the planning phase of lighting as compared to the mechanical adjustment which is often considered a staging operation. Methods of camera operation are guided to take advantage of controlled scene conditions in obtaining the best possible camera performance.

RULES FOR STAGING PRACTICE

1. The reflectance of large set areas and objects should be held between 25% and 50% for high-key scenes; between 10% and 25% for low-key scenes. Small details may range from 3½% (maximum black) to 70% (maximum white) reflectance. A 10-step, 20:1 gray-scale step wedge should be used as a reference standard.

2. Where colors are used, a limited number of samples should be

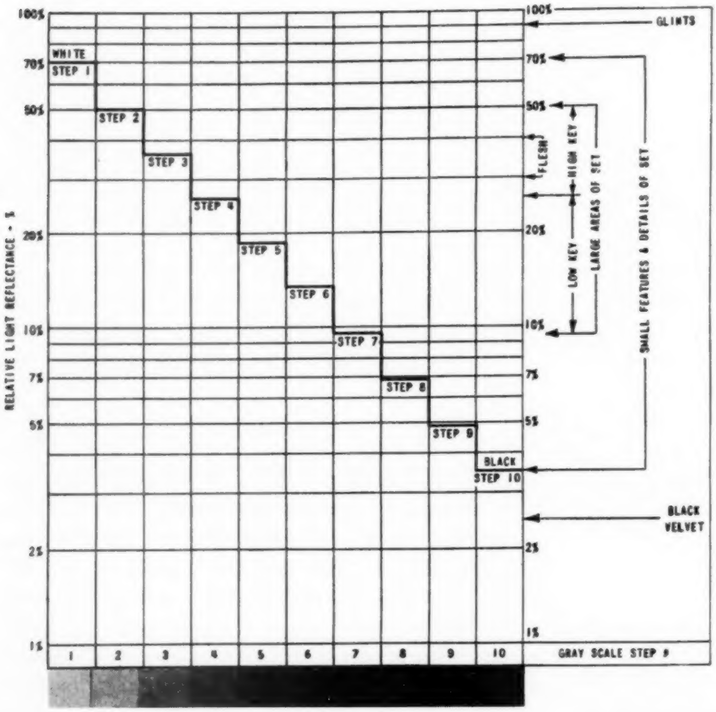

Fig. 5. Reflectance Values: Recommended reflectance value ranges for large and small scenery areas or objects are shown with respect to a 10-step, 20-to-1, reference gray-scale step-wedge. The total range for large scenery areas is held to 5 to 1 (approximately 10% to 50%) allowing for some additional variation from illumination distribution. Reflectance values indicated here are to be measured through a camera system by comparison with the calibrated gray-scale step-wedge, thus taking into account spectral distribution and surface texture.

selected and calibrated against the reference gray-scale by observation on a picture monitor.

3. Large adjacent areas should not differ in reflectance by more than 2 to 1 (2 steps on the reference gray-scale).

4. Large monotone areas, particularly dark ones, should be avoided or broken up with simple patterns, tree leaves, shadows, etc.

5. At least a small area of both extreme white and extreme black should be included in every scene to aid camera level adjustment.

6. Very dark or very white long horizontal lines or structures should be avoided.

7. Highly reflective areas or objects should be avoided or placed in

diffuse light against a light background and, if necessary, treated to reduce reflectance.

Discussion of Staging Practice

The reflectance* of scenery elements is keyed to performer's skin reflectance which is on the order of 30% to 40%[13] (Fig. 5). If large background areas are too light, electron redistribution within the image orthicon camera tube from such areas may cause faces to be darkened; if the scenery is too dark, electron redistribution and spurious effects in the camera tube arising from the faces may disturb the background. The total range of reflectance for large areas covers only a 5-to-1 ratio (10% to 50%), allowing for some additional variation in over-all luminance to be contributed by adjustment of illumination distribution.

The use of color in staging is unnecessary for monochrome television transmission. However, if used carefully—as merely another way of obtaining a certain gray tone on the picture tube—there are no objections to its use. Prior to the establishment of a color-sample precalibration procedure, there was at least one case where a studio setting was carefully worked out in beautifully contrasted colors only to appear on the air as a complete monotone (the designer's red face produced the only different tone). The human eye tends to confuse color contrast with brightness contrast and, unaided, is often a misleading judge of staging propriety. One technique found to be safe is to paint scenery in graded tones of a single pre-calibrated color. Color is in television scenery to stay, it being felt by many that a more natural atmosphere is provided for the performers. Although this is a moot point, the practical approach is to use color but to control it in terms of easily determined pre-calibrated gray response.

Electronic spurious effects in the camera tube are most noticeable where large contrasts and large dark areas are present. Bright objects in front of dark backgrounds are a severe problem. The reflectance of starched white cloth may run as high as 90%; that of jewelry, musical instruments and other polished objects may run close to 100%, exhibiting specular reflectance. These values are almost three times the reflectance of skin. In many cases, the highlight area itself may be controlled by: painting-off kitchen appliances; using blue, tan or off-white clothing and stage papers; using

* Reflectance is taken here to indicate nonspecular reflectance averaged over the range of wavelengths accepted by the type 5820 image orthicon tube, and measured by comparison with the reference gray-scale, observed through a camera channel.

Fig. 6–A. Excess top-light.

Fig. 6–B. Excess top-light.

Fig. 6. Excess Top-Light

Illustration A was photographed from a camera control monitor; B was photographed directly on the studio floor with the same lighting. The increase in contrast through the television system is noted in comparing the two photographs. The shadow detail present in the direct photograph is lost in transmission through the system. Lighting contrasts which can be used for direct photography are excessive in television. Strong overhead lighting is particularly to be avoided.

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matte surface stage photographs; or coating metallic surfaces with spray-wax or talcum powder. Bald heads may be toned down with make-up. In other cases, the background surrounding an uncontrollable high-light such as a piece of jewelry or a candle flame may be kept very light, being graduated off into darker areas of the scene.

It must be realized, of course, that maintenance of a limited range of reflectance among portions of a stage setting is only part of the story. The light which actually reaches the camera is a function not only of scenery reflectance but also of illumination level, which in turn must be held within its own set of limits.

Rules for Lighting Practice

1. The first step in lighting a television scene should be to establish a diffuse and uniform base-light throughout the working area, including backgrounds. Measured with a photocell meter aimed toward all camera positions from the various performer positions, the following levels should be obtained for use with the type 5820 image orthicon equipped with a Wratten No. 3 filter:

With 4500 K (degrees Kelvin) white fluorescent light, 100 ± 10 lm/sq ft*

With incandescent light (2870 K), 120 ± 10 lm/sq ft.

Components measured with the meter aimed vertically should not exceed the components measured with the meter aimed horizontally.

2. To provide depth, to separate objects and to add artistic interest, several types of effects-light should be added, usually from directional incandescent fixtures. The level of such components may be set to approximately the correct values by measurement with a photocell meter pointed toward the fixture from the performer positions with all other lights turned off, but should be set finally on the basis of appearance on a picture monitor.

Back-light: Should be directed from the lowest possible rear angle with an intensity between 1 and 1½ times base-light level. Vertical, top-light is not back-light and should be avoided.

* Lumens per square foot is numerically equivalent to the older term, foot-candles.

Fig. 7–A. Fluorescent base-light (100 ft-c including eye-light, E below).

Fig. 7–B. Incandescent back-light (1 × base).

Modeling-light: Should be directed from a side-front position; may be adjusted to just cause shadows and will usually require an intensity of between ½ and 1 times base-light.

Key-light: Similar to modeling but slightly more prominent—to give effect of a predominate source; may be from 1 to 2 times base-light level with base-light from the direction of the key-light fixtures reduced accordingly.

Eye-light: A very small amount of light to provide sparkle in a performer's eyes and to supplement the base-light for close-ups; usually from ½ to 1 times base level.

3. Where special lighting effects such as spot-lighting, lights-out dramatic sequences, or moonlight effects are required, base-light may be lowered to a minimum of ¼ normal level and any special effects-lights then adjusted to bring total illumination level at the point of interest between 1 and 1½ times the normal base-light level (meter aimed at camera).

4. Fluorescent (4500 K, white) and incandescent light sources may be intermixed without impairing color-response—where cameras are equipped with Type 5820 or 5826 image orthicons and blue-cutting filters such as Wratten No. 3. Incandescent sources may be dimmed to ¼ normal meter reading without impairing spectral response.

5. Self-luminous objects or areas such as exposed lamps, rear-lighted windows, or rear-projection high-lights shall be held (by dimming or other means) to produce, on a meter held a few inches from the area, a reading which does not exceed ¾ to 1 times the normal base-light level.

Discussion of Lighting Practice

Base-light corresponds to what often is called fill-light in motion picture practice. However, because of the contrast range and spurious response characteristics of the television system, this is the most important of all lighting components and it must be given the prominence of first attention—ahead of key- or other effects-light. The term, base-light, connotes the basic importance in television lighting of covering all picture areas with a very uniform illumination level. It is especially important that this base-light be uniform over the entire working stage area as viewed from all possible camera viewpoints and that it include low-angle front-light components. Where the reflectance of scenery and set fixtures is controlled, uniform, diffuse base-lighting will insure similar working conditions for all cameras on all sequences of a production. It has been found that these conditions can be adequately fulfilled with either fluorescent or incandescent

Fig. 7–C. Fluorescent base-light and back-light.

Fig. 7–D. Incandescent modeling-light alone (1.7 × base, strong enough to be key-light).

sources of light so long as good diffusion and even distribution are obtained. Mixtures of lighting types for this function are permissible. Excess top-light is to be particularly avoided as it is a prime source of electron halos and ghosts as well as darkened eyes and faces (Fig. 6).

Television pictures obtained with good base-lighting alone are technically good, but artistically incomplete. To achieve artistic quality, a relatively small amount of effects-lighting is required as compared with movie, legitimate stage or photographic practice. The television system cannot tolerate violent lighting contrasts; but, on the other hand, will produce pleasing results with relatively small intensity differences. The important technique is to use differences in quality or direction rather than brightness differences alone, to obtain the effect. There are an infinite variety of effects-light possibilities, and it is practical to catalog only a few very common types, with recommended intensities to indicate general technique (Fig. 7-A—G). In general, it is necessary to look at the result—on a picture monitor—not trusting direct visual observation on the set, to determine the effectiveness of any special lighting arrangements The eye accepts too wide a range of contrast to be a reliable measuring instrument. It is desirable that the lighting directors become accustomed to this practice, as one job they must often perform is to correct or supplement any staging conditions which do not register as desired.

As to color response, camera-tube developments have simplified this problem greatly.[3] Also, the subjective tolerance for visible color-to-gray distortion is actually somewhat greater than has been generally believed; most of television's notorious earlier troubles arose from erratic sensitivities of pickup tubes to nonvisible light components. At the present state of the art, it can be said that any light which appears reasonably white to the eye will produce satisfactory color-to-gray rendition on television. With a stage set having controlled reflectances, and with lighting which has been arranged to have a uniform base-light level with carefully adjusted artistic effects, the camera operating personnel are in a position, with a few additional precautions, to secure good results.

Rules for Camera Operation

1. The type 5820 image orthicon, used with a Wratten No. 3 filter, will require a normal lens aperture of from $f/8$ to $f/16$ when recommended light intensities are used. The exact lens setting should be adjusted to the point where the signals corresponding to maximum high-light areas just start to decrease in amplitude on the waveform monitor.

Fig. 7–E. Fluorescent base-light, back-light and modeling-light.

Fig. 7–F. Incandescent eye-light (including additional base-light measured as part of A).

2. All cameras used on a particular production shall be carefully adjusted to give matched gray-scale rendition against actual set backgrounds.

3. Image orthicon ghosts may be minimized by keeping the offending high-light in the center of the screen or, where necessary, by electron-image defocusing.

4. All control room monitors should be equipped with picture tubes of similar phosphor color and of similar voltage-to-luminance transfer characteristic. They should be adjusted to just go black with a blanking signal set to reference black amplitude. If in doubt, camera balance comparisons should be made on a single (line-output) monitor.

5. Signal levels should be carefully monitored to maintain true black-and-white signals at their respective reference levels, using the picture monitor to judge which peaks may be considered spurious or to judge conditions where no full peak signals exist.

Discussion of Camera Operation

Although some of the present-day image orthicon tubes will produce very satisfactory results from sets illuminated with only 20 to 30 lm/sq ft, there is about a 3:1 variation in sensitivity among tubes. To accommodate this range, to provide a margin for filter absorption and to accommodate special lens conditions, light intensities of the order of 100 lm/sq ft are recommended. Present practice is to use the lens stop to regulate exposure, contrary to the established motion picture practice of setting lens stop to achieve a required depth of focus. As pickup tubes become more uniform in sensitivity, this practice will undoubtedly be adopted in television. If necessary, base-light may be reduced to 50 lm/sq ft with appropriately wider lens apertures and if a uniform, diffuse distribution is maintained.

Although the sensitivity varies, the color response is quite uniform among present-day type 5820 and 5826 image orthicon tubes. The response of these tubes to infrared components is negligible and it has been found that a simple filter to remove the monochromatic mercury-line radiation present in fluorescent light enables satisfactory color match among various cameras and under various types of light. The Wratten No. 3 (or No. 6)[10] filter has been found to be a good compromise between effective blue-rejection and loss in the transmission band, a filter factor of one lens stop being applicable.

Color response differences now seem to be less of a factor in gray-scale matching among cameras than lens flare, scene luminance content or camera misadjustment. With excess exposure, a considerable

Fig. 7-G. Full base-light, back-light, modeling and eye-light.

variation in luminance transfer characteristic may result from adjustment of image orthicon target potential. The more positive the voltage above beam cutoff, the greater the range of input luminance which can be accommodated. At the same time, electron redistribution effects decrease as the target voltage is made more positive so there is much less change in over-all luminance transfer characteristic as the average scene luminance is varied. A limit to the potential of the target above cutoff is set by beam-current noise; beam current being increased in proportion to target voltage to discharge all high-light areas. However, the fact that camera target voltage adjustment does influence over-all transfer characteristic may be used within limits to correct an unfortunate staging or lighting circumstance. These effects, though more apparent in the close-spaced tubes such as the type 5826, have been found to apply in a limited way to the type 5820 which has a wider target to mesh spacing. Video gain and blanking level adjustments also affect over-all luminance transfer characteristics.

Television signal monitoring techniques are similar to audio practice in that two devices are used: one to measure levels, the other to determine quality. However, the technique of monitoring by observation of waveform and picture monitors, lacks the years of refine-

ment and widespread operational use which lie behind use of the audio volume indicator meter and the loudspeaker. At the present, television monitoring techniques are somewhat primitive. To make the best use of the present facilities in balancing gray-scale, average signal level, and black-and-white peak level among cameras, picture monitors must be carefully set up and waveform monitors carefully calibrated and interpreted. Where definite maximum whites and blacks exist in a scene, level monitoring is straight-forward. Where glints or small insignificant blacks exist, they may be adjusted to exceed their respective reference levels—requiring judgment of their importance as viewed on the picture monitor. Where a very flat image is desired there may be no peak levels of reference amplitude at all; the video gain and blanking controls again have to be set by judgment of the image seen on the picture monitor.

In such cases, the faces of performers should be used as the basis of judgment, the voltage waveform corresponding to such areas normally being held between ½ and ¾ of reference white level. It is unfortunate that no television equivalent of the standard audio volume indicator meter is available as yet. The importance of careful and accurate level monitoring is realized when it is considered that current practice calls for setting black peaks to a level which is 10% of total picture amplitude, a value which is only little more than the limiting accuracy in reading an oscilloscope. The dependence of image quality on careful camera adjustment and operation in no way lessens the requirement for careful staging and lighting practice. The technical job is made much simpler if the preceding steps have been done so as to minimize some of the problems, allowing concentration on the remaining ones. Achievement of uniform staging and lighting conditions makes possible optimum camera adjustment to obtain good results from all cameras throughout a show.

Summary

An understanding of the technical characteristics of the present monochrome television facilities makes possible control of staging, lighting and camera operation to achieve technically correct and artistically pleasing images. In particular, characteristics of the television pickup and transmission facilities establish boundaries on overall range of luminance values, on luminance differences among adjacent areas, and on the shape and arrangement of scenery features. By setting forth working rules grouped for the various production activities which are often separated in both time and location, production personnel are enabled to work separately toward a unified final result.

It is realized that working rules cannot cover all cases—that they are subject to early obsolescence in such a rapidly changing art as television. However, by pointing out the general approaches, such rules enable the experimentally minded production team to guide their very commendable striving for better effects away from known blind alleys or even to make use of the limitations themselves.

Results which exploit the capabilities of the present television facilities to the greatest possible extent can be obtained in everyday operation when the system characteristics are known and respected.

ACKNOWLEDGMENT

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Motion Picture Instruction In Colleges and Universities

A Follow-up Study of the 1946 Report by John G. Frayne

By JACK MORRISON
University of California, Los Angeles, Calif.

As the hot war of the 40's ended, there was much to be said about the growing use of film in education and about the teaching of film production in colleges and universities, with comprehensive curriculums supplemented by modern and suitably designed equipment. These views, in fact, were reflected in the Journal article by Frayne cited in the note below. As Chairman of the SMPE Motion Picture Instruction Committee, Frayne reported the motion picture courses taught in the 102 institutions, colleges and universities which answered his questionnaire. The purpose of the study was to report to the Society what courses were being taught and where. The article closed with comments as to the possible value of this education to motion pictures as a profession and noted in particular the lack of technical courses. As of three years later—three years of unparalleled expansion in higher education—the present investigation proposes to follow up the Frayne study for the purpose of indicating possible trends and offering a reasonably definite idea of the present state of instruction in motion pictures in American colleges and universities after this period of relatively lush growth.

In order to compare the two reports simply, the Frayne breakdown of courses is followed as originally conceived. The Frayne report (1946) appears on the left side of the tabulation immediately following, and on the right is the follow-up study (1949). In addition to the information about units and semester hours included in the 1946 report, the 1949 report has a brief description of each course.

Because certain schools not included in the 1946 study have since then introduced courses, and because schools which have increased the number of their courses since that time would not appear in the parallel type of reporting, two additional summaries are necessary for a more comprehensive consideration of the growth in the period. These listings below, are shown on p. 273 through p. 277. One is a recapitulation of the courses dropped since 1946, and the other is a listing of schools which were not reported in the Frayne study and which have introduced motion picture courses since 1946. Due to the newness of the field, it is impossible to say how many institutions offering motion picture courses are still *not* included in this report.

A Contribution: Submitted December 15, 1949. This follow-up study of "Report of the Committee on Motion Picture Instruction" by John G. Frayne, *Jour. SMPE,* vol. 47, pp. 95–106, Aug. 1946, was instigated by the American Educational Theater Association's Committee on Film, Radio and Television under the Chairmanship of Kenneth Macgowan and was reported at that Association's 1949 National Convention.

Colleges	1946 REPORT	1949 REPORT
	Courses in Cinematography (Including Color)	
New York University	*Motion Pictures 1 & 2:* 3 sem hr/wk; 6 cr.	*Cinematography:* Camera work, composition, lighting; general basic production course; 2 sem hr/wk.
Oregon State College	*Educational Cinematography* (Summer Session only): 3 term hr; 3 cr. 2 sem hr; 2 cr.	*Cinematography:* Production of classroom films to aid in teaching; 3 term hr.
University of Denver	*Motion Picture Making:* 2 qtr hr; 2 cr.	*Survey of Audio-Visual Materials & Equipment:* Description not available; 5 qtr hr.
		Film Techniques: Theory, principles and practice of camera techniques; lighting and composition; presentation of ideas, emotions and incidents by filmic means; creative application of movement, progression and tempo; individual projects in camera planning; 5 qtr hr.
		Motion Picture Production: An intensive study of all the mechanical and literary problems contributing to the actual producing of a motion picture; emphasis to be placed on the four major non-theatrical types of film—industrial, educational training and documentary; analysis of typical productions in each category with critical evaluation; development of a working script by the individual student for a projected picture in one of the categories; observation on location with the university film unit; 5 qtr hr.
Ohio State University	*Cinematography:* 2 sem hr/wk; 2 cr.	*Photography 515* (*Motion Picture Photography*): Lecture, laboratory, and practice in basic motion picture techniques; emphasis on 16-mm field; history of motion pictures, operation of cameras, types of lighting, film processing, elements of projection; 3 qtr hr.
University of Southern California	*Cinema 115AB:* 1st yr, 8 hr/wk; 8 cr. (and others, see bulletin)	*115AB* (*Camera I, II*): Theory, principles, and practice of camera techniques; lenses and their uses; lighting and composition; introduction to camera planning; 2 cr each.
	Cinema 165AB: 2nd yr, 8 hr/wk; 8 cr. (and others, see bulletin)	*165 AB* (*Camera III, IV*): Advanced problems in the use of lighting for dramatic effect; creative use of lenses and filters; planning camera continuity and selecting camera angles; practical work on current productions; 2 cr each.
	SUMMARY: 5 schools, 9 courses listed.	*SUMMARY:* 5 schools, 10 courses listed.

	Courses in Photography (Including Color)	
Iowa State College	*Physics 316 and 650*, (To develop photography in scientific fields): 4 1/2 cr hr for 316; 3 cr hr or more for 650.	*316 Photography:* Methods and practices in photography; composition and lighting; corrective treatment of negatives; printing; 3 qtr hr. *317 Photography in Journalism:* Methods and practices in photography; evaluating photographs for journalistic use; 3 qtr hr. *650 Photography in Scientific Work:* Methods of photography in specialized fields; choice of filters and plates; photomicrography; color photography; 2 to 6 qtr hr.
University of Oregon	*Rudiments of Photographic Journalism:* 1 1/2 sem hr/wk; 2 term cr.	*Physics 161 (Rudiments of Photography)*: Photography as an avocation; 3 qtr hr. *Journalism 451, 452, 453 (Graphic Journalism)*: Instruction in taking news pictures; use of pictures in the press; 2 qtr hr each.
Oberlin College	*Photography in the Department of Chemistry:* Lab 1 or 2 three hr periods/wk; 2 or 3 hr cr.	*Chemistry 12 (Photography)*: Photography primarily as a working tool for the scientist; 2 or 3 hr.
Baylor University	*Photography:* 3 1/2 sem hr/wk.	*Photography 151 (Introductory Photography)*: An introduction to photographic technique and its applications; fundamentals of photography and practice use of the dark room; 5 qtr hr.
University of Detroit	*P41b:* 3 sem hr/wk for 1 sem; 2 cr.	*Physics 41 B (Photography)*: Theory and application of the fundamental principles of photography; 2 hr.
University of Minnesota	*News Photography:* 3 qtr hr/wk; 3 cr. *Photography:* 5 qtr hr/wk; 3 cr.	*Motion Picture Photography:* Covers the requirements of good cinematography with laboratory sessions on proper editing techniques, special effects and titling; 3 hr. *Applied Photography:* Lectures, demonstrations and laboratory sessions on portraiture, architecture, landscape, news and illustration photography, retouching, mounting and darkroom work; 3 hr.
Gustavus Adolphus College	*211 Photography:* 2 sem hr/wk; 2 cr.	*Physics 211 (Photography)*: Taking and finishing pictures with particular emphasis on scientific aspects; laboratory work in development, printing, enlarging, color photography, making lantern slides, photomicrographs and retouching; 2 hr.
	212 Advanced Photography: 2 sem hr/wk; 2 cr.	*Physics 212 (Advanced Photography)*: Miniature camera techniques, advanced theory of development, hypersensitization, and chemical and physical reversal of photographic emulsions, advanced projection, toning and mounting of salon prints, development and printing of color film and 8-mm movie making and movie titling; 2 hr.

	1946 REPORT	1949 REPORT
Drake University	*News Photography:* 2 sem hr/wk; 2 cr.	*123 Pictorial Journalism:* Illustration of the news story by picture and diagram; the picture magazine, films and other media; 2 hr.
		124 Camera Journalism: Photography and use of pictures in newspapers, magazines, and syndicates; photographic field trips; 2 hr.
College of Emporia	*Photography in Physics Department:* 2 sem hr/wk; 2 cr.	*Photography:* Elementary theory and practice of making exposures, developing and printing; 2 hr.
University of Colorado	*Photography:* 2 sem hr/wk; 2 cr.	*News Photography:* Taking and processing pictures of news value; 3 qtr hr.
Brigham Young University	*Elementary Photography:* 5 sem hr/wk; 5 cr.	*Physics 26 (Theory and art of Photography):* Lectures; lab. in photographic manipulation, determination of characteristics of photographic materials; 4 hr.
	Advanced Photography: 3 sem hr/wk; 3 cr.	*Physics 187 (Advanced Photography):* Description not available; 2 hr.
State College of Washington	*Photography* (in planning stage at present).	No course listed.
Northwestern University	*Elements of Photography:* 4 qtr hr; 4 cr.	*D 18 Principles of Photography:* Fundamentals of photography, operation of press camera, development of films, making of prints, compounding of chemical solutions, use of standard photographic equipment and materials; 4 qtr hr.
	Press Photography: 4 qtr hr; 4 cr.	*E 10 Press Photography:* Advanced course; professionally supervised study practice of techniques followed by press photographers; 4 qtr hr.
New York University	*Motion Pictures 3 & 4:* 2 sem hr/wk; 4 cr.	No course listed.
Colgate University	*Photography:* 3 sem hr/wk; 3 cr.	*Physics 239 (Photography):* Gives not only a practical understanding of scientific principles of photography but also shows the importance of the media in conveying ideas; 4 hr.
Miami University	*Elementary Photography (Still):* 2 sem hr/-wk; 2 cr.	*Principles of Photography:* Basic theoretical and practical course; 6 hr.
	Advanced Photography (Still): 4 sem hr/wk; 3 cr.	*Photography:* Hobby level course; 2 hr.

Oregon State College	*Ph 161* (*Rudiments of Photography*): 2 term hr; 2 cr.	*Physics 161* (*Rudiments of Photography*): Based on college physics or chemistry; hand camera, developing, printing, enlarging, slides, etc.; 2 qtr hr.
	Ph 361 (*Hand Camera*): 3 term hr; 3 cr.	*Physics 361, 362, 363* (*Photography*): 361—The hand camera, developing, printing, toning, enlarging, slides;
	Ph 362 (*Commercial*): 3 term hr; 3 cr.	362—Commercial phases of photography; view cameras, copying, flashlights, indoor lighting, color correction, etc.;
	Ph 363 (*Composition Enlarging*): 3 term hr; 3 cr.	363—The making of pleasing pictures; composition, carbon and carbo, paper negatives, enlarging negatives, etc.; 3 qtr hr each course).
	Ph 461, 462, 463 (Advanced Photography; Color, Photomicrography, Microscopic Motion Pictures): 3 term hr; 3 cr.	*Physics 461, 462, 463* (*Advanced Photography*): Color, photomicrography, microscopy, motion pictures, miniature camera technique; 3 qtr hr (each course).
University of Idaho	*Photographic Technique, Zool. 151–152* (Does not include motion picture but includes color-correct photography and some color photography): Sem I, 3 sem hr/-wk; 3 cr. Sem II, 2 sem hr/wk; 2 cr.	"We offer . . . some work in photography . . . intended for the research type of student."
St. Olaf College	*Photography and Art:* 4 sem hr/wk; 2 sem cr.	No course listed.
Ohio State University	*3 courses:* 3 sem hr/wk (each course); 3 cr (each course).	*511 Photography:* Use of the camera, characteristics of photographic emulsions, light filters and their uses, exposure problems, processing of negatives, contact printing, etc.; 3 qtr hr. *520 Engineering Photography:* Application of special photographic techniques; use of visual aids in the presentation of engineering data; production of blueprints, photostats, etc.; 3 qtr hr. *625 Scientific Photography:* Nature of photographic processes, characteristics of photographic materials and the application of photography to science; 3 qtr hr. *650 Advanced Photography:* Projection printing, portraiture, special effects, photo-engraving, lens testing, color photography, miniature camera work and motion pictures; 3 qtr hr. *699 Minor Problems in Photography:* Use of library and laboratory facilities for student to add to his knowledge and technique in some subjects in photography and to carry out minor investigations; 3 to 5 qtr hr (may repeat up to 10).

	1946 REPORT	1949 REPORT
University of Southern California	*Cinema 90, 91, 92:* 4 sem hr/wk (each course); 2 units (each course).	*50AB* (*Fundamentals of Photography*): First semester—Photographic optics and chemistry, sensitometry, composition and lighting; Second semester—individual projects, theory and practice in composition, lighting, enlarging techniques and applied sensitometry; 2–2 hr.
		92 Portraiture: Individual projects; techniques and art of portraying character and personality; dramatic lighting, camera angles, posing, use of background, make-up, retouching; 2 hr.
	Cinema 121AB: 4 sem hr/wk (each course); 2 units (each course).	*121AB* (*Color Photography*): First semester—Theory of color separation, densitometry and calibration of negative materials, lighting, exposing and developing separation negatives; Second semester—Densitometric evaluation of the negative, sensitometric evaluation of the positive, printing developing and mounting the positive, demonstration of carbo and wash-off processes; 3–3 hr.
	SUMMARY: 21 schools, 40 courses listed.	*SUMMARY:* 21 schools, 42 courses listed.
	Courses in Sound Recording	
Georgia Institute of Technology	*Public Speaking* (Part of course).	No course listed.
State College of Washington	None, except in courses offered in radio techniques.	No course listed.
New York University	*Motion Pictures 9 & 10:* 2 sem hr/wk; 4 cr.	No course listed.
Oregon State College	*Education 533* (Correlation of radio recordings with visual aids): 3 term hr; 3 cr.	No course listed.
University of Southern California	*Cinema 140:* 3 sem hr/wk; 2 cr.	*140AB Sound, I, II:* First semester—Principles of sound recording for motion pictures, types of equipment, production techniques, recording, playback, and scoring; Second semester—recording channels, microphones, amplification, transmission, disc and film recording units, effect of equalizers, distortions and discriminations in equipment and processes; 2–2 hr.
	SUMMARY: 5 schools, 4 courses listed.	*SUMMARY:* 5 schools, 2 courses listed.

	Courses in Motion Picture Film Editing	
New York University	*Motion Pictures 31:* 2 sem hr/wk; 2 cr.	*Film Cutting and Editing Theory:* Laboratory study of sound and silent film; 2 hr.
University of Southern California	*Cinema 135:* 3 sem hr/wk; 2 cr.	*135AB Editing, I, II:* Equipment and techniques of motion picture editing; use of standard editing equipment; principles and mechanics of procedures; 2–2 hr.
		185AB Editing, III, IV: Advanced problems in creative editing; practical work on current productions; 2–2 hr.
Antioch College	*Motion Picture Film Editing:* 20 wk; 5 cr.	No report received.
	SUMMARY: 3 schools, 3 courses listed.	*SUMMARY:* 2 schools, 5 courses listed.
	Courses in Motion Picture Projection	
Pennsylvania State College	*Teach 16-mm projection* (But not for credit).	"Elementary techniques of projection are taught in one of the Visual Education classes."
University of Kentucky	Given both informally upon request of individuals and included in educational audio-visual instructional aids courses.	*Education 186* (*Visual Teaching*): Methods and techniques of visual instruction; (slides, still pictures, motion pictures, etc.); 3 hr.
New York University	Included in Motion Pictures 3 & 4.	No course listed.
Antioch College	Classes conducted by students under extra-curricular committee	No report received.
	SUMMARY: 4 schools, no courses listed.	*SUMMARY:* 3 schools, no courses listed.
	Courses in Motion Picture Distribution	
Pennsylvania State College	*Motion Picture Distribution.*	No course listed.
University of Kentucky	Included in graduate courses on audio-visual aids in instruction. Commercial distribution for entertainment is not included.	No course listed.
New York University	*Motion Pictures 19 & 20:* 2 sem hr/wk; 4 cr.	No course listed.
University of Southern California	*Cinema 150:* 2 sem hr/wk; 2 cr.	*150 Distribution and Exhibition:* Survey of merchandising principles as they apply to films; advertising, trailers, exchanges, exhibiting, theater management; 2 hr.
	SUMMARY: 4 schools, 4 courses listed.	*SUMMARY:* 4 schools, 1 course listed.

	1946 REPORT	1949 REPORT
	Courses in Economic Problems in Motion Picture Production and Exhibition	
New York University	*Motion Pictures 19 & 20:* 2 sem hr/wk; 4 cr.	No course listed.
University of Denver	Courses planned for 1946–1947 in School of Commerce.	No course listed.
University of Southern California	*Cinema 250 AB:* 2 sem hr/wk for 2 sem; 2 units/sem.	*183 Cinema and Society:* Influences of the American film on social groups in the United States and abroad from 1890 to the present; influences of the society on the cinema; 2 hr.
		199 Unit Management: Production planning, breakdown and scheduling; cost estimates and location problems; 2 hr.
		225 Studio Production Control: Supervision of writing, production and editorial departments; 2 hr.
	SUMMARY: 3 schools, 4 courses listed.	*SUMMARY:* 3 schools, 3 courses listed.
	Courses in Film Processing (Still)	
University of Detroit	A part of the lab work of General Photography.	No course listed.
State College of Washington	In planning stage.	No course listed.
University of Southern California	Covered in Cinema 90, 91, and 92.	Covered in "Fundamentals of Photography," "Photoportraiture," and "Color Photography."
	SUMMARY: 3 schools, no courses listed.	*SUMMARY:* 3 schools, no courses listed.
	Courses in Film Processing (Motion Picture)	
Oregon State College	Included (16-mm) in course in Photography.	No course listed.
	SUMMARY: 1 school, no course listed.	*SUMMARY:* 1 school, no course listed.

Courses Dropped by Schools Since the 1946 Report

School	*Course*
Cinematography	
New York University	Motion Pictures 1 & 2
Ohio State University	Cinematography
University of Denver	Motion Picture Making
Photography	
Baylor University	Photography
Drake University	News Photography
New York University	Motion Pictures 3 & 4
St. Olaf College	Photography and Art
University of Oregon	Rudiments of Photographic Journalism
University of Southern California	Cinema 90 & 91
Sound Recording	
New York University	Motion Pictures 9 & 10
Oregon State College	Education 533
Motion Picture Distribution	
New York University	Motion Pictures 19 & 20
Pennsylvania State College	Motion Picture Distribution
Economic Problems in Motion Picture Production and Exhibition	
University of Southern California	Cinema 250AB

Courses Reported Since the 1946 Report

(Includes Schools Not Reported by Frayne)

Cinematography	
Baylor University	Drama 388 The Film
College of the City of New York	Films 13 Fundamentals of Film Production
Drake University	Ed. 108 Audio-Visual Education Materials and Methods
New School for Social Research	Elements of Cinematography
New York University	Cinematography
Ohio State University	Motion Picture Photography
Stanford University	The Technique of the Motion Picture
University of California at L. A.	Motion Picture Photography and Sound
University of Denver	Ed. 336 Survey of Audio-Visual Materials and Equipments; Film Techniques
University of Minnesota	Motion Picture Photography
University of North Carolina	Motion Picture Production
Western Reserve University	Motion Picture Production
West Virginia University	Ed. 251 Cinematography
Photography	
Boston University	News and Feature Photography; Advanced News and Feature Photography; The Preparation of Photographic Materials for Visual Education
Brooklyn College of the City of N. Y.	Design 45 Photography I; Design 46 Photography II
College of the City of New York	Motion Picture Photography; Advanced Motion Picture Photography
Columbia University	Science 169P Photography for Teachers
Cornell University	An introductory course in photography

Courses Reported Since the 1946 Report, cont'd

Depauw University	Composition and Photography
Drake University	Pictorial Journalism; Camera Journalism
Indiana University	Creative Photography; Elementary News Photography; Practical Work in News Photography; News Photography; Picture Editing
Kansas State College of Agr. & App. Sc.	Photography
Miami University	Photography
Ohio State University	Engineering Photography; Scientific Photography
South Dakota State College of Agr. & Mech. Arts	Photography
Texas Christian University	Photography
Tulane University (Newcomb College)	A Camera Department
University of Mississippi	Ed. 19d/e The Use of Photography in Teaching
University of New Mexico	Art 87 & 88 Photography
University of North Carolina	Elementary Photography
University of Oregon	Physics 161 Rudiments of Photography; Journalism 451, 452, 453 Graphic Journalism
University of Southern California	Fundamentals of Photography
West Virginia University	Physics 216 Photography
Sound Recording	
Brigham Young University	Radio Production and Recording; Radio Sound Recording
College of the City of New York	Film Music and Recording
Indiana University	Radio Broadcasting 278AB
Ohio State University	511, 512 (sound-on-film recording in 16-mm)
Pasadena City College	Radio Controls Laboratory 40
University of Southern California	140B Sound II
Motion Picture Film Editing	
Baylor University	Film and Television Production
College of the City of New York	Motion Picture Editing; Advanced Motion Picture Editing
University of California at L. A.	Motion Picture Editing 165AB
University of Southern California	135B Editing II; 185AB Editing III, IV
Motion Picture Projection	
Boston University	The Operation and Maintenance of Audio-Visual Equipment
Brigham Young University	Education 275 Audio-Visual Instruction
Iowa State College	Audio-Visual Methods in Education
Oregon State College	Audio-Visual Teaching Aids
University of Virginia	Ed. 57 Visual and Auditory Materials of Instruction
West Virginia University	Ed. 221 Audio-Visual Resources for Instruction
Motion Picture Distribution	
College of the City of New York	Distribution and Publicity in Motion Pictures
Indiana University	Administration of a College Center of Audio-Visual Materials
New School for Social Research	Operating the Film Library
University of Virginia	Ed. 159 Administration of Audio-Visual Programs
West Virginia University	Ed. 322 Organized Programs of Audio-Visual Instruction

Courses Reported Since the 1946 Report, cont'd

Economic Problems in Motion Picture Production and Distribution	
Boston University	Administration of a Motion Picture and Audio-Visual Aids Dept.
New School for Social Research .	Film Production Methods
University of Southern California	Cinema and Society; Unit Management; Studio Production Control
Film Processing (Still)	
South Dakota State College of Agr. & Mech. Arts	Photography 58AB
University of Colorado	News Photography
Film Processing (Motion Picture)	
University of Southern California	101AB Laboratory Practices and Procedures
Motion Picture Acting	
New School for Social Research .	Acting for Film, Television and Radio
University of California at L. A..	Acting for the Motion Pictures
Screen Writing	
Boston University	Writing of Motion Pictures and Filmslides
College of the City of New York	Motion Picture Writing; Advanced Motion Picture Writing
Columbia University.	F. A. Motion Picture; Scenario Writing and Production
New School for Social Research .	Basic Screenplay Writing; Advanced Documentary Writing; Feature Screenplay Writing Seminar
New York University	Writing the Screen Treatment
Stanford University	Technique of the Motion Picture
University of California at L. A. .	Writing for the Screen 166AB
University of Southern California	Screenwriting I, II, III, IV; Educational Screenwriting; Documentary Screenwriting; Seminar in Screenwriting
Western Reserve University . .	Practices in Script Writing
Motion Picture Directing	
College of the City of New York.	Motion Picture Directing
New School for Social Research .	Film Direction
New York University	Intermediate Motion Picture Production
Stanford University	Technique of the Motion Picture
University of California at L. A. .	Fundamentals of Motion Picture Direction
University of Southern California	Cinema Directing I, II, III, IV; Seminar in Motion Picture Direction
Motion Picture Lighting	
University of Southern California	115AB & 165AB (Camera Classes)
Educational Film	
Boston University	The Use of Audio-Visual Aids in Education
College of the City of New York	The Documentary Film as an Educational Tool
Columbia University.	Science Films; Production of Educational Motion Pictures
Indiana University	Utilization of Audio-Visual Materials; Selection of Audio-Visual Materials; Administration of Audio-Visual Materials; Production of Audio-Visual Materials; Administration of a College Center of Audio-Visual Materials; Seminar in Audio-Visual Materials;

Courses Reported Since the 1946 Report, cont'd

Indiana University, *cont'd.*	Research in Audio-Visual Materials; Thesis in Audio-Visual Materials; Workshop in Administration of the Audio-Visual Aids Program
Louisiana Polytechnic Institute	Use of Audio-Visual in the Classroom
New School for Social Research	Audio-Visual Aids in Education
Oregon State College	Construction and Use of Audio-Visual Aids
University of California at L. A.	Educational and Documentary Film Techniques
University of Denver	Survey of Audio-Visual Materials and Equipment; Survey of Instructional Motion Pictures; Administration and the Supervision of the Audio-Visual Program
University of Kentucky	Visual Teaching; Motion Pictures in Education
University of Southern California	276AB Workshop in Educational Film Production
University of Wisconsin	Methods of Audio-Visual Instruction
Documentary Film	
College of the City of New York	Fundamentals of Film Production
University of California at L. A.	Nature and History of the Documentary Film
University of Southern California	208AB Documentary Production; Documentary Direction
Animation	
New School of Social Research	Graphics and Animation
University of California at L. A.	Fundamentals of Motion Picture Animation; Animation for Educational and Documentary Films; Animation for Entertainment Film
University of Southern California	148AB Principles and Mechanics of Animation
Film History and/or Aesthetics	
Boston University	The History of Motion Pictures
College of the City of New York	The History of Motion Pictures
New School for Social Research	March of Film; Seminar in Film Techniques
New York University	Introduction to Motion Pictures
Purdue University	English 52 The Art of the Motion Pictures
Stanford University	History and Aesthetic Development of Motion Pictures
University of Connecticut	The Art of Motion Pictures
University of Southern California	Introduction and Survey of Motion Pictures 60AB; Filmic Expression 105AB; Cinema History and Criticism 200AB; Seminar in Creative Cinema 274AB
Wayne University	History and Appreciation of Motion Pictures
Film Appreciation	
Baylor University	Introduction to Drama, Television and Film
Columbia University	Ed. 162 PRD, Photography and Radio Drama as Communication Arts; Ed. 209 MF, International Film Series
Fordham University	Motion Picture Appreciation and Criticism
Miami University	Motion Picture Appreciation
New School for Social Research	Basic Principles of the Mass Communication Arts; March of Film
New York University	Motion Picture Literature
Syracuse University	Cinema Appreciation
University of California at L. A.	Visual Analysis
University of Delaware	Theater, Film and Radio
University of Denver	Film Arts

Courses Reported Since the 1946 Report, concl'd

University of Iowa	Cinematography
University of Kansas	The Motion Picture
University of Minnesota	Film and Drama; Humanities 52
University of Oregon	Appreciation of Drama
University of Toledo	Appreciation of the Motion Picture
Film Design	
New School for Social Research	Applied Stagecraft for Film and Television
Otis Art Institute	Motion Picture and Television Art Institute
University of California at L. A.	Motion Picture Costume Design; Motion Picture Design and Draftsmanship 167AB
University of Southern California	Art Directing I, II, III, IV; Art Direction 210AB
Survey of Film Production and Techniques	
Boston University	Workshop in Motion Pictures and Visual Aids; Motion Picture and Television Film Production
Columbia University	Production of Educational Motion Pictures
New School for Social Research	Film Production Methods
Pasadena City College	Stage Technology
University of California at L. A.	Motion Picture Survey; Film Technique
University of Denver	Motion Picture Production
University of Southern California	Motion Picture Production Techniques 175AB
University of Wisconsin	Local Production of Audio-Visual Materials
Miscellaneous	
Baylor University	Television and Film Workshop 207ABC
Boston University	Research in Motion Pictures and Audio-Visual Aids; Audio-Visual Aids in Health and Physical Education; Visual Presentation of Ideas; Principles of Motion Pictures and Audio-Visual Aids in Public Relations and Business
College of the City of New York	The Documentary Film in Labor Relations; Practice in Film Production
Columbia University	Audio-Visual Materials and Methods of Use; Lab Course in Audio-Visual Instruction; Administering the Use of Audio-Visual Materials
New York University	Advanced Individual Study
Stanford University	Stage and Screen
Texas Christian University	Research Problems in Speech-Drama
University of California at L. A.	Motion Picture Makeup; Elementary Motion Picture Workshop; Advanced Motion Picture Workshop; Summer Motion Picture Workshop 179CDE; Theory of Educational Film
University of Southern California	Motion Picture Technology; Cinematic Effects 153AB; Makeup for Motion Pictures; Public Relations in Motion Pictures; Unit Management; Production 205AB; Seminar in Motion Picture Engineering 211AB; Studio Production Control 225; Films for Television
Wayne University	Advanced History and Appreciation of Theater History

In conclusion, it may be safely said that despite the fast-growing attention given to the motion picture in education, the schools included in the Frayne study indicate little if any significant change in the teaching of the production of motion pictures in colleges and universities in the years from 1946 to 1949. Although the follow-up study reported 300 motion picture and "related" courses compared with Frayne's report of 86, it is possible that the number of institutions offering a comprehensive major in motion picture production is less than a half-dozen. This is probably a reflection of expense of equipment, lack of personnel and antipathy toward "trade school" courses.

Frayne's point that few technological courses are offered continues to be well founded. While it may be argued whether motion pictures is an art, a profession or a craft, there still does not appear to be enough study of the technical phases to assure motion pictures becoming understood and used as the distinctive educational tool it promises to be.

A great number of the courses added have been in audio-visual aids. It is obvious that the relationship between motion pictures in particular and audio-visual aids in general needs clarification. For example, one development to be noted in the follow-up study is the recurrence of a one-semester omnibus course which not only teaches a student all the phases of making a motion picture, but requires him to complete one as a project in the course. While this may serve a certain situation well, its effect on the development of motion picture production should be scrutinized carefully.

Finally, attention should be called to the lack of a generally accepted nomenclature in the field. This lack seriously impaired the effectiveness of this as well as the Frayne study. Attention to nomenclature, course description in relation to curricular concepts, and clarification of relationships to visual aids would be well worth the while of the American Educational Theatre Association's Committee on Film, Radio and Television and the University Film Producer's Association.

Synchronous Recording On 1/4-In. Magnetic Tape

By WALTER T. SELSTED

Ampex Electric Corp., San Carlos, Calif.

SUMMARY: This article discusses the problem of synchronizing motion picture film with a sound track on standard ¼-in. magnetic recording tape. The equipment for synchronizing the tape with film is the major subject discussed.

The use of magnetic tape for recording motion picture sound tracks has by now aroused great interest within the film industry. The system of recording a sound track directly on optical film is unnecessarily costly and risky and will soon be obsolete. Only too frequently retakes are necessary because of failure on the part of a performer or in later film processing. Failure to get a perfect track results in a great waste of film, time and developing cost. Magnetic recording can replace film recording entirely for sound track work and will save the industry a great deal of money.

Early work with magnetically recorded sound tracks was done with standard 35-mm motion picture film coated on one side. Later, the film was split down the center to save one-half of its cost. However, the cost of split 35-mm magnetic recording film is ten times as high as standard ¼-in. unperforated tape. This difference in cost makes the latter recording medium appear to be most desirable if it can be used. Not only can it be used, but it has several other important advantages over the perforated tape, aside from that of cost. Storage space is reduced by 7½:1 over the split 35-mm magnetic tape. Recording time per reel is increased by 2½:1. Weight per reel is reduced by 2½:1.

As everyone in the film industry knows, the problem of sprocket perforation flutter is a major problem which required considerable work to overcome. The use of ¼-in. magnetic tape for sound track recording eliminates this problem as well. The manufacturers of magnetic recording materials have stated that the magnetic coating cannot be applied to 35-mm film as uniformly as it can on ¼-in. tape. The greater uniformity obtainable on tape results in lower amplitude modulation of the recording and better high-frequency response. The 35-mm film base has approximately nine times the stiffness of ¼-in.

Presented: April 24, 1950, at the SMPTE Convention in Chicago.

tape. This greater stiffness results in poor head contact and consequent further amplitude and frequency response variations not found in using standard tape.

To be of any use to the motion picture industry, it is necessary to synchronize the sound track with the picture. Since no sprockets can be used with ¼-in. magnetic tape, one must magnetically or optically mark the tape so that it can be reproduced later at a controlled rate. The optical methods of tape synchronizing normally utilize bars or spots on the back surface of the tape as guides to control the speed of playback and hence allow it to be synchronized with the film. The systems thus far tried using this type of tape marking are satisfactory except during starting. Due to the fact that the photoelectric sensing devices do not know whether the tape at start is running faster or

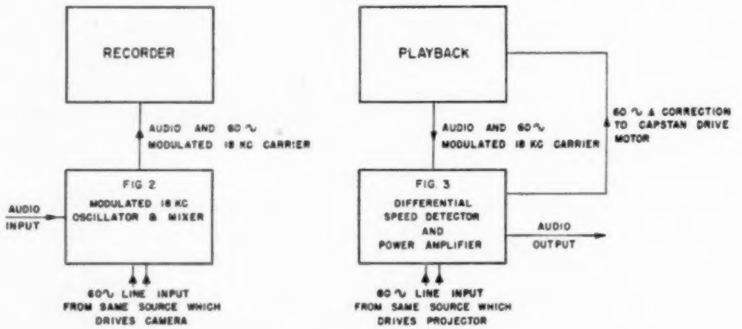


Fig. 1. Tape synchronizing system.

slower than synchronous, it is impossible for the sensing system to control the tape drive during starting. The lip-synchronous equipment described herein utilizes a magnetic marking system which has the advantage that it will without attention from an operator come to film-synchronous speed from standstill in a time corresponding to normal starting time for the associated recording equipment.

Figure 1 is a block diagram of the tape synchronizing system developed to be used with a standard Ampex Model 300 tape recorder. On the left side of Fig. 1 the block marked "Recorder" is a standard tape recorder without any modifications whatsoever. The block marked Fig. 2 is a small, lightweight, auxiliary unit which marks the tape magnetically during the time the original sound track is recorded. It will be noted that the audio signal to be recorded is fed into this unit marked Fig. 2 and before entering the recorder has added

to it an 18-kc carrier which is modulated by the frequency of the power line used to drive the picture recording camera. In Fig. 1 this is the input marked "60-cycle line input." However, the system will operate properly if some frequency other than 60 cycles is used. After making a recording with this setup, the tape contains the intelligence as well as 60 cycles riding on an 18-kc carrier. The relationship between the 60-cycle signal and the audio intelligence is the same relationship as the picture on the film recorded by the film camera bears to the same 60-cycle frequency. Hence, if during playback the 60-cycle signal on the magnetic tape can be held in fixed relationship with the power-line frequency driving the projection

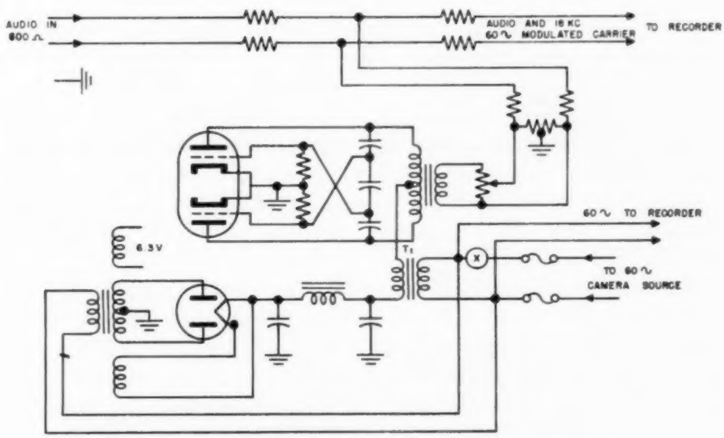


Fig. 2. Modulated 18-kc oscillator and mixer.

camera, the sound and picture will remain in a synchronous relationship. Figure 2 shows the electrical circuit of the modulator unit used with the recorder. It consists of a push-pull 18-kc oscillator, which is amplitude modulated by the 60-cycle line frequency through the modulation transformer, T_1. Mixing of this modulated 18-kc carrier with the incoming audio frequency is accomplished by the balanced attenuator network shown in the upper portion of the figure.

Referring to Fig. 1 again, the block marked "Playback" represents the recorder when used as a playback machine. When a tape, which has been previously recorded with the equipment shown on the left side of Fig. 1, is played back, the output from the machine contains the audio intelligence and the 18-kc amplitude modulated carrier.

This signal is fed into the equipment shown in Fig. 3 which is the differential speed detector and power amplifier. This equipment controls the speed of the playback so that the rate at which the tape travels is exactly the same as the film playback. In Fig. 3 the block breakdown of the equipment used for this purpose is shown. In the upper left corner, the output of the playback amplifier enters the speed control system. In passing through the 18-kc rejection filter, the carrier and its modulation are removed, leaving only the audio intelligence at the output terminals. Before the 18-kc rejection filter, a tap is made which takes the 18-kc modulated carrier and the audio to the

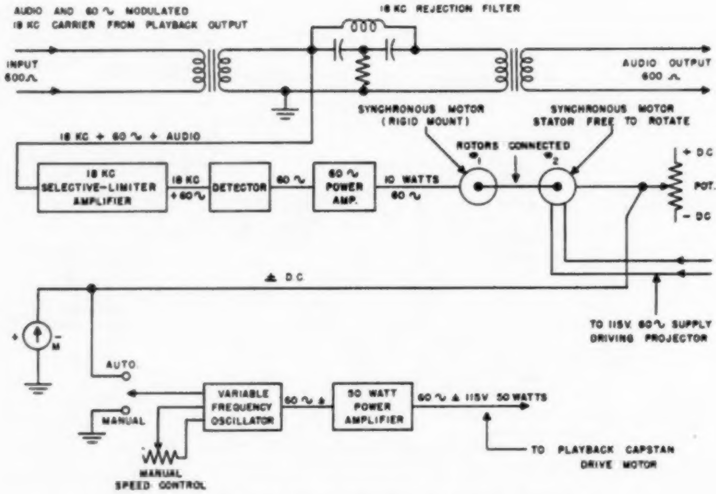


Fig. 3. Differential speed detector and power amplifier.

input of the 18-kc selective-limiter amplifier. Output of this amplifier feeds a conventional full-wave detector circuit which delivers at its output the approximately 60-cycle line frequency. The word "approximately" is used in this case because thus far we have not considered where the correction in the tape speed occurs. The 60-cycle output from the detector drives the power amplifier which delivers approximately 10 watts of power at 60 cycles. This amplifier has in its output stage two 6V6-type tubes. The heart of this synchronizing equipment lies in the use of the two synchronous motors shown at the output of the 60-cycle, 10-watt amplifier. The synchronous motor which receives its input from the 10-watt amplifier

is mounted rigidly. The output shaft of this motor is directly connected to the output shaft of an identical motor, but the second motor is mounted in such a way that its stator is free to rotate through approximately 180 degrees. When its stator rotates it operates the potentiometer shown to the right of these two motors. The second motor obtains its input from the 60-cycle supply used in operating the projector which is projecting the film associated with the sound on the tape being reproduced. The potentiometer driven by the stator of the second synchronous motor supplies a variable d-c voltage to the variable-frequency oscillator shown in the lower left corner of Fig. 3. The variable-frequency oscillator consists of a standard multi-vibrator which has a normal frequency of approximately 60 cycles. The output 60 cycles from the variable-frequency oscillator drives the 50-watt power amplifier, which in turn powers the playback capstan motor. This amplifier uses two Type 807 tubes in the output stage.

Assume for the moment that a tape has been threaded into the playback machine. This tape has previously been recorded by the equipment described in Fig. 2 at the same time that a picture film was made. When the playback equipment is started, the second synchronous motor will begin to operate and turn the potentiometer in such a direction as to increase the frequency of the variable-frequency oscillator. The output frequency of the 10-watt, 60-cycle amplifier will within approximately 0.1 sec be greater than 60 cycles, resulting in a rotational speed difference between the two motors which will very quickly turn the stator of motor number two in the opposite direction from that in which it first started to move, and correct the frequency of the variable-frequency oscillator so that the output derived from the tape exactly matches the power line frequency. When the frequency of the power feeding both of the two motors is identical, there is no resultant rotation of the stator of motor number two. This is the static condition which exists during normal playback. Assume that the frequency derived from the tape was 0.1% low. Then the synchronous motor number one would operate at a slower speed than synchronous motor number two, resulting in a slow change in the position of the stator of number two, which in turn, results in a change in the variable-frequency oscillator which will increase its frequency and hence correct the tape speed.

If it is necessary to cue the sound with the picture, for example during playback of a television show, it is possible to start the equipment a short time before or after the camera is started and have the sound track very closely match the picture. If, however, after starting, the

picture does not synchronize with the sound, that can be very easily corrected by the manual speed control associated with the variable-frequency oscillator. If the operator finds that a correction is necessary, he will make it by turning the manual speed control until the meter in the lower left corner indicates zero. At this time he throws the automatic manual switch to "manual," and increases or decreases the speed of the tape to synchronize it with the picture. When the picture has been thus synchronized, he readjusts the meter to zero, throws the automatic manual switch to the "automatic" position, and allows the automatic correction to carry on from there.

This equipment is designed specifically for use with any Ampex recording equipment and permits its use without requiring any modification of the standard recording equipment. The savings realized through the use of $\frac{1}{4}$-in. magnetic tape for sound track recording far outweigh the cost of this additional control equipment, and through the use of magnetic tape the motion picture industry can realize even higher quality sound recording than it has in the past.

Electrical and Radiation Characteristics of Flashlamps

By H. N. OLSEN and W. S. HUXFORD
Dept. of Physics, Northwestern University, Evanston, Ill.

SUMMARY: Measurements of flashtube current and potential have been obtained using a radar synchroscope, and from these the power and energy supplied to the discharge for a wide range of operating conditions. Simultaneous observations of the time variation of the radiation in three spectral regions were recorded using multiplier phototubes. A lag of several microseconds in peak radiation behind peak power input is observed, the lag increasing with wavelength of the intense continuum produced by these discharges in rare gases. In addition to this change in quality of the radiation with time during the flash period, an increase in radiation efficiency with energy input occurs, the rate of increase being the highest for short wavelengths.

The most intense light source commonly available is the brilliant flash produced by the discharge of a condenser through a gas at reduced pressures. The spectrum of the radiation emitted is a continuum upon which a few emission lines are superimposed. In appearance the light is an intense white and produces an effective duplication of daylight illumination for photographic purposes. During the recent war, high current flashtubes were used extensively in reconnaissance photography. More recently rapid advances have been made in the application of gaseous discharge flashlamps in high-speed photography.[1] They are commonly employed for stroboscopic work and have recently been used in airport runway marker systems.

Intensities as high as 10^6 candles/sq cm have been obtained in single flashes in lamps where the average power input is 10 megawatts during the period of the flash. Light output efficiencies of the order of 50 lumens per watt have been measured in single-flash, high-current discharge tubes.[2]

The present report is concerned with electrical and radiation characteristics of flash discharges in quartz tubes filled with rare gases having pressures in the neighborhood of 100 mm Hg. Current, potential, and power input to the discharge, and light output as measured by means of phototube multipliers, were recorded on an oscilloscope screen. A triggering circuit has been designed to produce synchronous current pulses with a repetition error less than 0.1μsec (microsecond). Repetitive flashing at rates of from 1 to 60 flashes/sec were used in these experiments.

Presented: April 26, 1950, at the SMPTE Convention in Chicago.

Radiation efficiencies are found to increase rapidly with energy input in the visible and ultraviolet regions. In the present work separate radiation–time curves for the ultraviolet, visible and near infrared regions were obtained. In all cases the radiation reaches a peak several microseconds after the peak input power, the maximum emission occurring at progressively later times the longer the wavelength.

APPARATUS

Synchronous Pulse Generator

The equipment used for synchronous operation of flashtubes is shown in the block diagram, Fig. 1. A 10-in. disc of Dow metal is driven

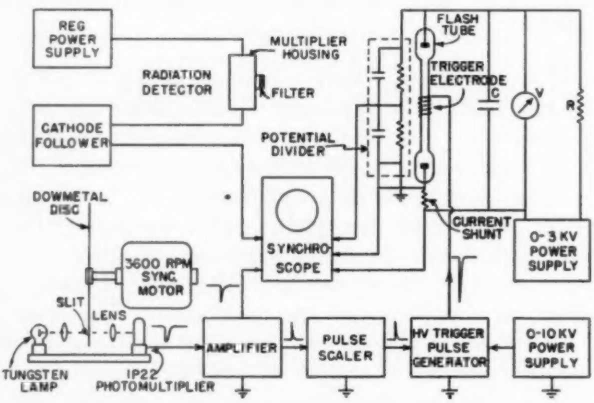


Fig. 1. Block diagram of apparatus.

at 3600 rpm by a Bodine Electric Co. $\frac{1}{20}$-hp synchronous motor. A 0.2-mm radial slit on the periphery of the disc passes light from the linear filament of a GE Mazda, 75-v, 4-amp movie exciter lamp to an RCA 1P22 photomultiplier tube to provide sharply defined current pulses. These pulses are amplified and used to trigger the oscilloscope sweep and also to initiate the discharge in the flashtube.

A scaler circuit provides pulsing rates lower than the 60 pulses/sec set up in the multiplier. It consists of six binary stages so arranged that any desired number may be inserted in the circuit to reduce the pulsing rate by a factor 2^n, where n is the number of stages used. Thus, in addition to the 60 pulses/sec initial rate six other rates of 30, 15, 7.5, 3.75, 1.88 and 0.94 pulses/sec are available. In this

manner a wide variety of flash energies may be employed, permitting the average power input to the flashtube to be kept low enough to prevent overheating or excessive sputtering of electrode materials.

The flashtubes had plane parallel electrodes 17 cm apart, separated by a quartz envelope 16 cm long with an internal diameter of 4 mm. Most of the data here reported were obtained with tubes filled with neon or argon at a pressure of 75 mm Hg. The electrodes were connected permanently to a condenser charged to a potential less than the breakdown voltage ($\sim$ 4000 v) of the gases used. The discharge is initiated by the application of a very rapidly changing potential to an external "trigger" electrode located near the center of the quartz envelope. The action of the rapidly changing field is to produce sufficient ionization of the gas for a discharge to occur, and the condenser potential decreases in a few microseconds from an initial value of 1500–3000 to a few hundred volts. The dielectric strength of the un-ionized gas is restored in a few tenths of a millisecond after the initiation of the high-current arc. A power supply is used which is adequate to charge the condenser to the original potential between recurring discharges.

Control and Measuring Circuits

Figure 2 gives a detailed diagram of the pulse network, the current shunt and the potential divider circuit arrangement, and the multiplier phototube connections to the synchroscope.

To provide high-voltage pulses for initiating the discharge, the amplified photo-current pulses from the scaler circuit are transformed to very sharp positive pulses by an RCA 884 thyratron. These pulses are then impressed upon the grid of a Western Electric 5D21 hard tube pulse tetrode, normally biased to cut off, reducing the plate impedance from a high to a very low value. The trigger electrode is connected directly to the plate of the 5D21 tube and through a one-megohm resistor to a variable high-voltage supply. When a positive pulse reaches the grid the tube conducts and causes a sharp reduction in the potential of the external electrode from several thousand volts to a very low value. Observations using the fast sweep of the synchroscope indicated that the change occurs in less than 0.1 μsec, or at a rate greater than 10^{11} v/sec. It was possible in this manner, using 6000 to 8000 v on the trigger electrode, to pulse successfully all the tubes used in this work in a perfectly consistent manner at any arbitrary rate for which overheating of the electrodes did not occur, and for observation periods of an hour or more.

All measurements were made with a Navy radar synchroscope

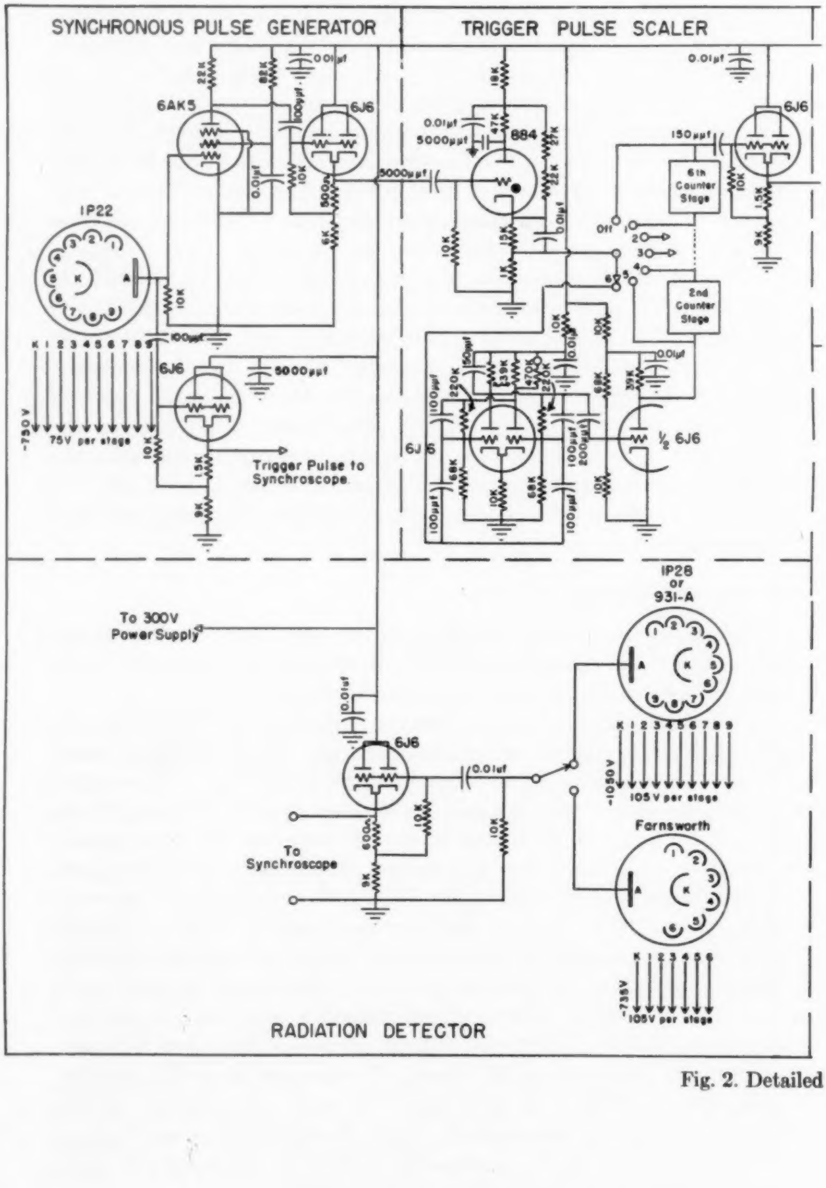
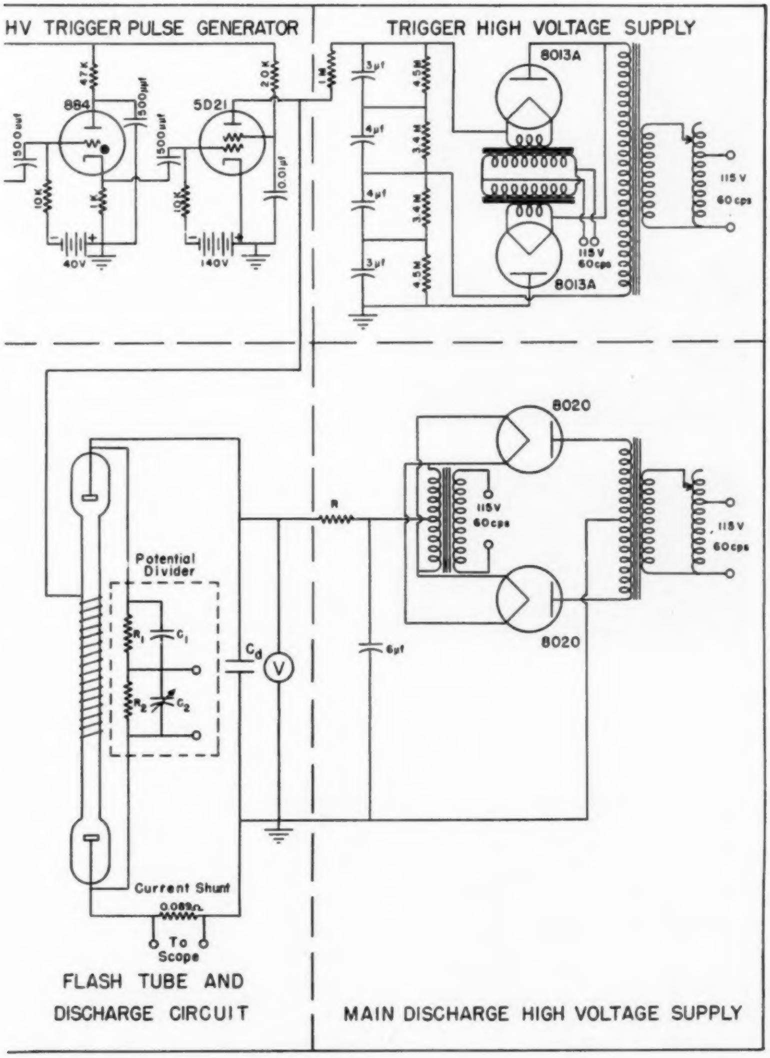


Fig. 2. Detailed



circuit diagram.

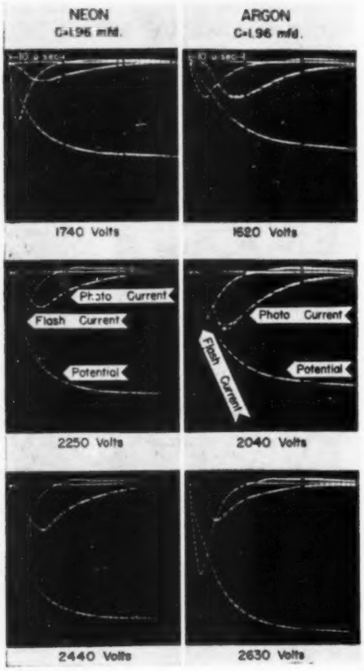


Fig. 3. Synchroscope traces of flash current, potential and photo-current.

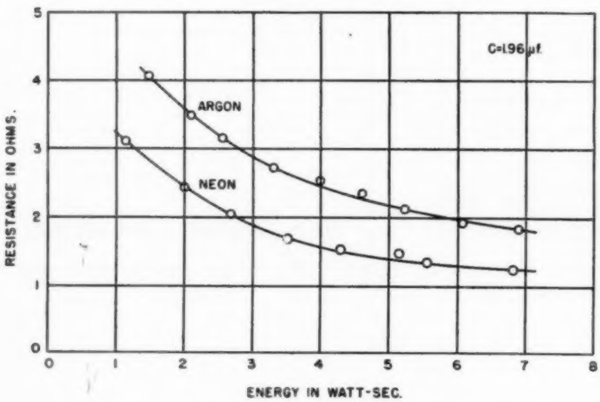


Fig. 4. Variation of tube resistance with flash energy.

Model TS–28/UPN having sweep ranges of 1–2, 10, 25 and 60 μsec/in., and provided with time markers. The sweep was triggered by means of a positive or negative pulse from the pulse generator circuit. The low-impedance input circuits were properly matched with well shielded coaxial cables. Care was taken to use identical cables in order to give correct phase relations between current, potential and light pulses. Direct connections to the deflection plates were made at a terminal strip on the back of the instrument.

The experimental data were obtained from photographs of the synchroscope screen showing the synchronized recurrent traces of potential, flash current and photo-currents due to the emitted radiation. Successive exposures on the same negative were made of all pertinent traces for a given set of conditions in the flash-tube circuit. These photographed traces of the current, potential and radiation pulses are thus recorded on the same negative in the correct relative phase relationship.

Measurement of tube potentials was carried out by means of a compensated and shielded high-resistance voltage divider. Space does not permit a detailed description of this unit and of the care taken in determining the correct method of its use in the flash circuit.[3] Check measurements showed that tube potentials read from the synchroscope photographs were in error by not more than $\pm 5\%$ for values above a few hundred volts.

Current pulses were obtained by the use of a specially constructed bifilar shunt element having a resistance of .089 ohm. Such elements are commonly employed in measuring heavy lightning surge currents.[4] Peak pulse current values determined from oscilloscope traces were checked against magnetic link measurements. The greatest difference at high values of current, where errors due to self-induction in the shunt are largest, was about 8%. The average deviation in mean current values as determined by comparing the charges delivered by the condenser with the charges obtained by graphical integration of the synchroscope current trace amounted to $\pm 3\%$.

For radiation measurements in the ultraviolet region an RCA 1P28 multiplier phototube was used in conjunction with a Corning 9863 filter to give an over-all response extending from 2400 A (Angstrom units) to 4200 A with a peak at 3350 A. For the broad "visible" region an RCA 931–A multiplier was used without filter. A narrow visible band was obtained by using the 1P28 multiplier with a Wratten K–3 (No. 9) filter which limited the response to the region between 4600 A and 7000 A. A six-stage Farnsworth multiplier with Cs-Ag-O cathode was used in conjunction with a Wratten A (No. 25) filter to

provide a response ranging from 6000 A to 12,000 A with a peak at 8500 A in the near-infrared region.

Since peak light intensities ranging up to 10,000,000 lumens are encountered at the highest flash energies, considerable attenuation was required to limit the operation to the region of linear response of the multipliers. A fixed amount of attenuation was provided by placing a piece of exposed photographic film over the opening in the multiplier housing. For controlling the photomultiplier currents during a series of measurements ranging from low to high peak light intensities a neutral Eastman Kodak filter having calibrated sectors was employed. In the present study light intensities are expressed in arbitrary units in each of the three spectral regions.

EXPERIMENTAL RESULTS

Figure 3 shows typical photographs of current, potential and photo-current traces for flash discharges in neon and argon. Exposure times of from 40 to 60 sec were required, so that at the repetition rate of 0.94/sec, each trace represents a large number of recurring discharges. The sharpness of these composite traces indicates the very precise manner in which the discharge repeats itself.

In these pictures the photo-current trace was obtained with the 931-A multiplier phototube and denotes radiation emitted in the broad visible range. Peak light intensities lag behind peak currents by about 5 μsec at low potentials. This lag decreases as the input energy per flash is increased. The main objective of the present investigation was to study in detail the changes in intensity and quality of the radiation with energy input and with time during the flash period.

Flashtube Resistance

Following the method of Murphy and Edgerton,[5] a quantity is used which we have called the "tube resistance." It is defined by the relation

$$R_t = V_m/I_m , \tag{1}$$

where I_m is the value of maximum flash current, and V_m is the potential difference between the electrodes at the time of peak current.

The variation of R_t with energy input per flash in neon and argon flashtubes of identical size and gas pressure is shown in Fig. 4.

It is found that the flash current decays in an exponential manner according to the equation

$$i = I_{\max}\epsilon^{-\lambda t}, \tag{2}$$

where the values of λ are given, within a mean error of $\pm$ 20%, by the relation

$$\lambda = 1/R_t C. \tag{3}$$

This shows that the rate of discharge of the capacitance, C, is very closely that to be expected in an RC circuit in which R is equal to the "tube resistance" defined in Eq. (1).

Energy Supplied to the Discharge

In order to determine radiation efficiencies, the fraction of the capacitor energy actually consumed in the discharge must be known. The power delivered to the tube as a function of time is calculated

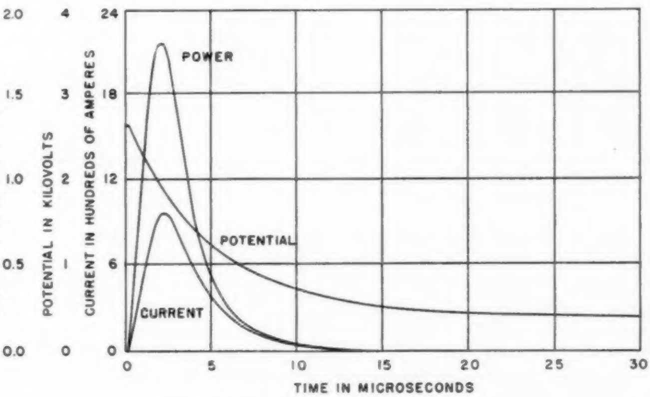


Fig. 5. Computed power–time curve.

from the product of simultaneous values of current and potential. An example of a power curve obtained in this way from replotted synchroscope traces is shown in Fig. 5. Graphical integration of the power curve yields, for each flashing condition, the energy delivered *per flash* to the discharge.

Energy calculations were carried out for one neon tube and one argon tube; three capacitors were used with potentials ranging from 1000 to 3000 v. The results appear in Fig. 6, where energy in watt seconds per flash is plotted against peak current values, both scales being logarithmic. Within the limits of experimental error, energy per flash is proportional to peak current, for a constant value of capacitance and variable voltage.

The measured energy consumed by the discharge differs from the energy of the charged capacitor by a fraction of one per cent at low potentials, and increases up to 15% at high potentials. The discrepancy will be much greater in circuits where lead wires of minimum length are not employed. In the present experiments the losses in leads and condensers correspond to those in a resistance of the order of 0.1 ohm in addition to the .089-ohm resistance of the current shunt.

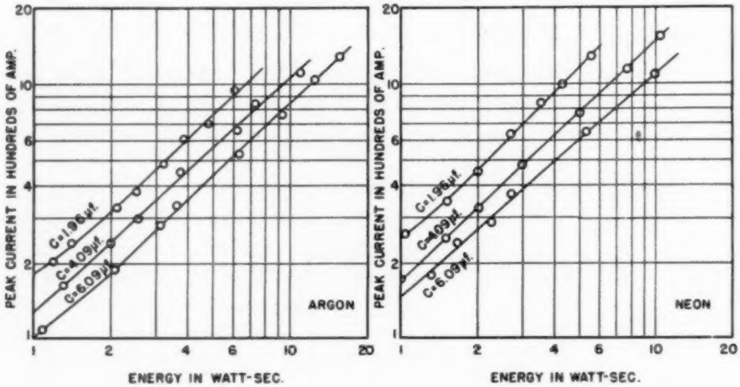


Fig. 6. Peak current vs. measured energy per flash.

Radiation Intensity vs. Input Energy

Measurements of the intensity of emitted radiation averaged over the entire flash period, determined either from single flashes or by using repetitive flashing, have shown that the following relation holds approximately:

$$\bar{S} = cW^n . \tag{4}$$

Here $\bar{S}$ is the average (integrated) intensity, c is a constant for a given tube, W is the energy of the charged condenser, and $n \gg 1$, its value depending upon the filling gas and spectral quality of the radiation reaching the phototube.

Examples of such results are shown in Fig. 7 for GE FT–14 xenon-filled flashtubes. Curves (a), (b) and (c) were obtained in this laboratory at low pulse rates ($\sim$ 10 pulses/sec), using widely different values of capacitance. Readings were made using a 931–A phototube multiplier, and light intensity and flash energy are expressed in arbitrary units. Curve (d) is taken from results published by Edgerton, and the

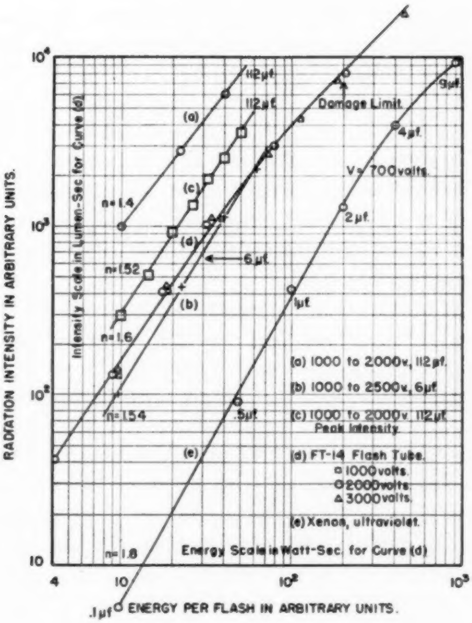


Fig. 7. Radiation intensity vs. capacitor energy for GE xenon flash lamps.

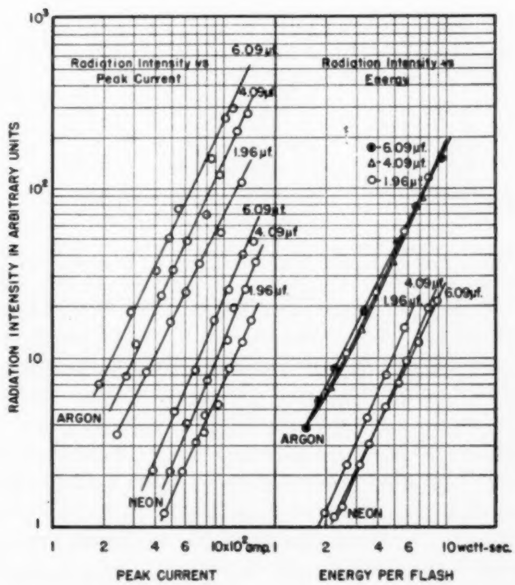


Fig. 8. Radiation intensity vs. peak current and flash energy for argon and neon.

integrated radiation is given in lumen-seconds as a function of the condenser energy per flash in watt-seconds. The value of n in all of these plots is about 1.5.

If an ultraviolet filter is used, light in the near ultraviolet region can be recorded. The FT–14 Tubes have a pyrex envelope and protecting outer chimney of pyrex, so that short-wave ultraviolet light is not transmitted. For this radiation the plot of Fig. 7 (e) was obtained, the slope of which yields the value $n = 1.8$. A large number of measurements on similar xenon-filled tubes of pyrex yielded a mean value of $n = 1.77$.

Additional measurements using a Farnsworth multiplier and infrared filter showed that $n = 1.0 \pm 0.1$ for xenon flashtubes. Hence, in the near infrared spectral region the efficiency is constant, the light intensity increasing linearly with flash energy.

The results of measurements of the integrated radiation emitted by argon- and neon-filled quartz tubes made in this laboratory, using a 931–A multiplier with no filter, are shown in Fig. 8. The mean value of n for argon is 2.15; for neon, 2.3. When measurements were carried out in the three spectral regions with the photomultiplier tubes and filters, described under Apparatus above, the results shown in Table I were obtained for radiation integrated over the entire flash period.

TABLE I. Value of n *in the equation* $\bar{S} = cW^n$

Region	Spectral Range	Mean Values of n	
		Neon	Argon
Ultraviolet	2400– 4200 A	2.8	2.3
Visible.	4600– 7000 A	2.1	1.8
Infrared	6000–12,000 A	1.6	1.2

Phase Lag of Light With Respect to Flash Current

Ultraviolet radiation peak intensities and to a lesser extent peak visible light intensities in both neon and argon were found to increase more rapidly with flash energy than do the mean values of the integrated light intensities. In addition, these peak values occur earlier in the flash period the shorter the mean wavelength of the spectral region. This is indicated very clearly in the synchroscope traces of Fig. 9 for photo-currents in the three multipliers for identical flashing conditions. In these plots photo-currents representing light intensities in the three regions of the spectrum have been plotted so that peak values are nearly the same. Light intensities are comparable

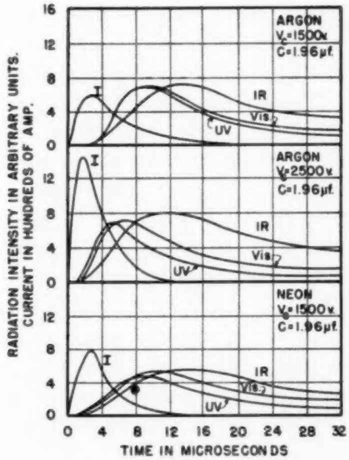


Fig. 9. Photo-current traces in three spectral regions.

only for any one trace; actually the intensities are highest in the ultraviolet, nearly as high in the visible and much lower than either of these in the infrared region.

Discussion

There are two aspects of the results obtained in this work which are of importance in the use of flashtubes for photographic and illumination purposes, and which require consideration in a detailed analysis of the discharge process. The first is the rapid increase in radiation efficiency with energy input, the increase being greatest for short wavelengths. A study of flash discharges in capillary tubes reported by Hahn and Finkelnburg[7] showed that the intensity of the continuum at all wavelengths increased as the *square* of the current density for densities greater than about 70,000 amp/sq cm. These authors believe that this continuum is largely due to the retardation of electrons in the fields of the ions in the discharge plasma (Bremscontinuum).

Observations in this laboratory of the nature of line spectra emitted by flash discharges show that, in the decaying portion of the radiation pulse, recombination of electrons and ions is occurring at a rapid rate. This process, involving "free-bound" transitions between electrons and ions, must also contribute to the observed continuum. The fact that radiation intensities vary not simply as I_{max}^2 (where I_{max} is the peak current), but as I_{max}^n, where n varies from 1.2 to nearly 3.0 depending on wavelength, indicates that probably the exciting elec-

trons undergo considerable change in velocity distribution during the flash period thereby modifying the simple quadratic relationship predicted for Bremsstrahlung and recombination continuua.

The second aspect to be noted is the fact that peak radiation occurs at different times depending on the spectral region observed. This phenomenon suggests the conception that the densely ionized plasma radiates as a "gray body" and exhibits a spectral maximum which is temperature dependent. Early in the discharge cycle the radiation peak is in the ultraviolet region indicating a high electron temperature. With cessation of current flow the plasma cools rapidly due to radiation, conduction and convection, and due also to the rapid expansion of the hot gases in the discharge column. As the mean electron temperature falls, the radiation peak shifts to longer wavelengths much as in the case of incandescent solids. Observations of electron excitation temperatures, both as a function of time during the flash and as a function of the energy supplied to the discharge, are being carried out in this laboratory in an attempt to correlate these two aspects of the condensed flash discharge.

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The Cine Flash

A New Lighting Equipment for High-Speed Cinephotography and Studio Effects

By H. K. BOURNE

Mole-Richardson (England) Ltd., London, England

and E. J. G. BEESON

The British Thomson-Houston Co. Ltd., Rugby, England

SUMMARY: A new form of portable lighting equipment is described which has been designed especially to meet the needs of the high-speed cinephotographer who is always faced with the difficulty of obtaining sufficient light. Two compact-source mercury cadmium lamps are operated in series at their normal wattages of 1 kw, and are then flashed at 3, 5 or 10 kw for 5, 2 or 1 sec. The equipment consists of a control unit and two lightweight lamphouses.

The light output is sufficient for color photography at speeds up to 3000 frames/sec, or for black-and-white photography with small lens apertures to give considerable depth of focus. The flash may be triggered from a microswitch or from a camera switch. The steady light output from the lamps is sufficient to arrange and focus the subject.

Methods of Illumination

For the scientific photographer the high-speed cinecamera is a valuable and potent tool enabling him to study extremely rapid motion with ease and certainty.[1] Projection of the cinefilm at a low speed enables the apparent movement to be slowed down so that it can be followed by normal vision. Using this technique, or that of projection frame by frame, a detailed analysis of the motion can be made and data such as the velocity, acceleration and position of the object under observation at various instants may be obtained. To the designer of machinery in particular, the technique of high-speed cinephotography has proved invaluable; without it many of his more difficult problems would still remain unsolved. Also, in the science of ballistics many advances may be attributed directly to the use of the high-speed cinecamera.

The chief applications of high-speed cinephotography lie in the fields of science and industry.[2] Modern high-speed cameras used in the majority of these applications generally operate at speeds up to 3000 frames/sec. At such speeds the exposure time is extremely short: only $\frac{1}{15000}$ sec at 3000 frames/sec. Such a short exposure

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time necessitates an extremely high illumination; for example, even with a very rapid film such as Kodak Super XX, an illumination of some 10,000 ft-c (foot-candles) will be required to expose an average subject with an aperture of $f/2.8$ at 1500 frames/sec. Owing to the slow emulsion of color film, it is even more difficult to provide sufficient illumination for high-speed color cinephotography, and the photographer is continually faced with the problem of obtaining enough light to allow a small enough lens aperture to give adequate depth of focus. Fortunately in many applications of high-speed cinephotography the subject is small in size and an illuminated area of only 6 to 12 in. in diameter is often sufficient. It is fortunate too that at these high speeds long periods of exposure are rarely necessary and useful total exposure times generally lie between 1 and 5 sec. It thus appears that a lamp providing up to 100,000 ft-c over an area of not more than 1 ft in diameter, for a duration up to 5 sec, would satisfy many of the needs of the high-speed cinephotographer. Because many of the applications are in factories, laboratories and industrial organizations, light weight, robustness and portability are other essential requirements for the equipment.

The difficulty of obtaining adequate illumination was stressed in this Society's Symposium[3] which included a number of valuable papers dealing with various aspects of the subject. In one paper dealing with lamps for high-speed photography, the requirements of the ideal light source were outlined and the paper then described the various methods which are being used for providing illumination. Each of these methods has certain limitations.

In the past, photographers have generally used standard film-studio incandescent spotlights for lighting the subject. For example, one M-R 414 Fresnel-lens spotlight with a 5-kw incandescent lamp produces approximately 10,000 ft-c over a 12-in. diameter spot at a distance of 5 ft. It is however, difficult to group enough spotlights closely together to obtain sufficient illumination; again, heating of the subject is extremely severe so that special means of cooling are often necessary. Another interesting but expensive method of lighting used in the United States[4] is to produce a short continuous flash by successive firing of a number of aluminum foil flashbulbs mounted on a rotating disc and passing in turn in front of a mirror. Highly loaded, short-life filament lamps intended only for intermittent burning have also been employed successfully.[5] The electronic flashtube is another light source which provides an extremely high light intensity but the duration of the flash is only a few microseconds so that, while it is eminently satisfactory for taking

Fig. 1. 1–10-Kw pulse-type compact-source lamp.

single high-speed still photographs, it is not suitable for cinephotography.[6]

None of the above methods meets all the requirements of the high-speed cinephotographer. The development of the discharge lamp has made possible a new means of obtaining a sufficiently high light output by flashing the lamp at a high overload, and special equipment has been designed to utilize this principle.

Certain technical problems necessitate ultra-high-speed photography at speeds far higher than 3000 frames/sec. Special cameras

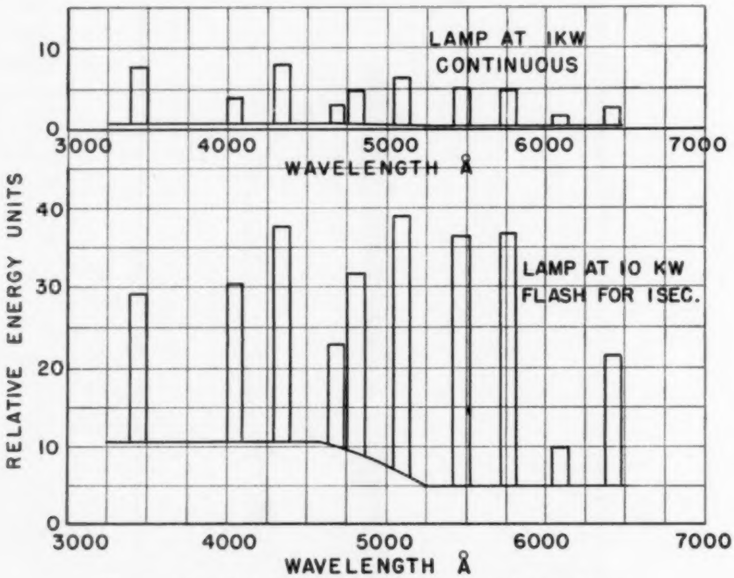

Fig. 2. Spectral distribution of mercury cadmium lamp.

are required, together with still higher lighting intensities. In this field, too, the new lighting unit described in this paper should be more effective than other sources hitherto available.

THE COMPACT-SOURCE LAMP

The compact-source mercury vapor lamp which is available in sizes from 250 to 10,000 w in England is now also becoming known in the United States.[7] A typical lamp, which is shown in Fig. 1, consists of a spherical transparent quartz bulb containing mercury and a rare gas filling. Two tungsten electrodes between which an arc operates are sealed into the bulb and the current is led in by molybdenum foil seals diametrically opposite to one another. Brass caps are fitted at the end of the seals. Connections are made through a flexible lead to the anode and through the special base to the cathode of the lamp. The light source itself is small in size and has a brightness of approximately 35,000 candles/sq cm with a luminous efficiency of 45 to 50 lumens per watt. At the normal rated power the life of the lamp averages 500 hr. An important feature of the compact-source lamp is that it may be operated for short periods at ratings greatly in excess of its normal power, and under these pulsed conditions it produces a correspondingly high light output.[8]

The radiation from a compact-source mercury vapor lamp is dis-

continuous and consists mainly of yellow, green and blue lines superimposed on a relatively weak continuous spectrum. Owing particularly to the deficiency in red content this light source produces a distorted rendering of colors but a considerable improvement in the color rendering can be obtained by the addition of cadmium in the discharge.[9] The discharge in cadmium vapor produces a powerful red line in the spectrum, while the gaps in the blue-green region of the mercury spectrum are filled by additional lines, so that the color of the radiation is better balanced. The color rendering also improves with increased current density in the arc so that the higher the wattage of the lamp the better is the color rendering. This improvement is due partly to broadening of the lines and partly to an increase in the amount of continuum at the higher current density. Spectral distribution diagrams of the mercury cadmium lamp operating at 1 kw and at 10 kw are shown in Fig. 2. These diagrams show that gaps still remain in the spectrum, but in spite of these gaps practical tests have shown that mercury cadmium compact-source lamps operating at powers above 2.5 kw give a satisfactory rendering of color with Kodachrome Daylight and similar emulsions.

Cinephotography Illuminator

A portable equipment using the principle of flashing a compact source lamp has been designed specifically to meet the illumination requirements of the high-speed cinephotographer. One equipment, known as the M-R 356 Cine Flash, illustrated in Fig. 3, consists of two lamp heads mounted on stands, and a control unit containing the ballast resistance and other components for operating the lamps.

The lamphouse, an interior view of which is shown in Fig. 4, is of a light sheet-metal construction. It contains a compact-source lamp mounted along the axis of a paraboloidal mirror and is fitted with a front diffusing glass. This optical arrangement gives a high light collection efficiency combined with uniform distribution. The mirror is made of metal so that it is robust and not liable to damage during transport of the equipment. By releasing the locking screws at the rear of the lamphouse, the lamp may be removed through the front of the housing for transport. The high-frequency choke required for the impulse striking circuit is mounted behind the mirror in the lamphouse.

The lamp is mounted in a prefocused holder and the focal position is set normally to produce a spot 10 in. in diameter at a distance of 4 ft from the unit with an illumination constant to within $\pm 15\%$ over its area. A fixed rather than variable focus ensures that the light output from the unit is constant so that the photographic exposure

Fig. 3. Cine Flash Equipment.

can be repeated accurately by setting the lamp at predetermined measured distances from the subject. In cases where it is necessary to cover a wider area with the lamps, the spread can be increased approximately threefold by using a front glass giving greater diffusion, but the light intensity is reduced to approximately $1/10$ in this case. A polar distribution curve of the equipment operating at 1 kw with the standard diffusing glass is shown in Fig. 5.

The light source is a color-modified mercury cadmium compact-source lamp normally rated at 1000 w but it differs from the standard type in that it has been designed specifically for this flashing service. The bulb is similar in design and dimensions to a standard lamp but special massive electrodes visible in Fig. 1 are provided to withstand

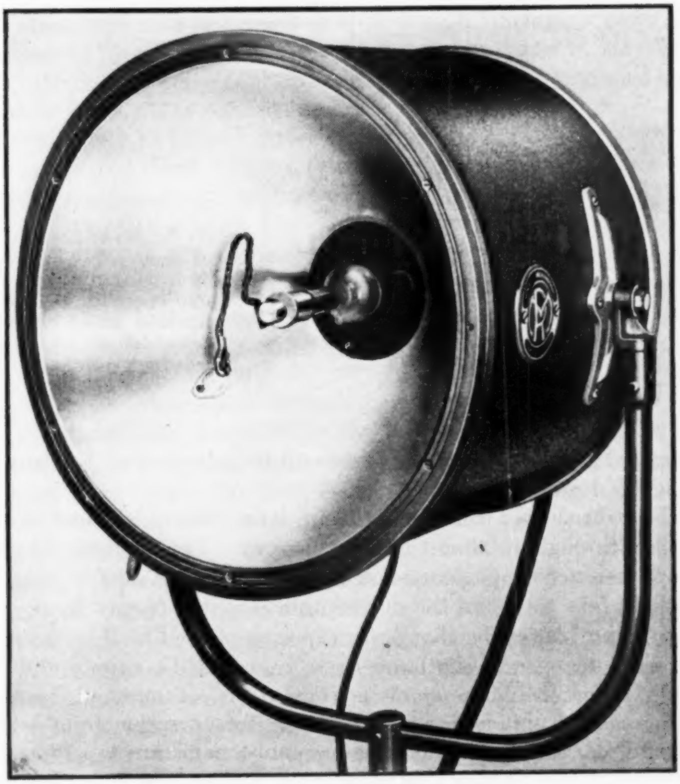

Fig. 4. Lamphouse with front glass removed.

the heavy overload conditions of flashing without fusing and consequent blackening of the bulb. A special construction giving good heat conduction is used to prevent melting of the electrode tips during the pulse. The very high current density in the flash condition ensures that the color of the radiation is good. As repeated flashing causes a further slight increase in the red content due to additional evaporation of cadmium at the higher bulb temperature, the color of the radiation does not stabilize completely until the lamp has been flashed several times in succession. Before taking a color photograph with this equipment, to ensure the best color rendering, it is therefore advisable to stabilize the color of the radiation by flashing the lamp several times. Alternatively the bulb may be preheated by a continuous moderate overload of some 50% for 30 sec. The overload is applied by depressing a push button; when this button

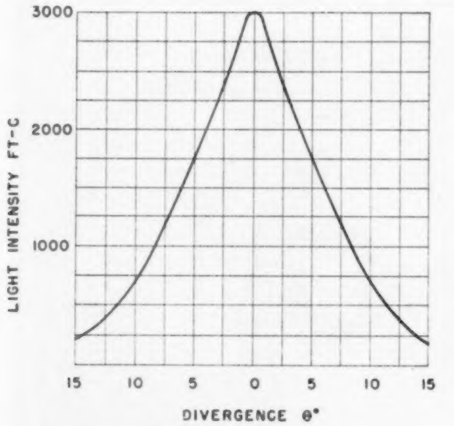

Fig. 5. M-R 356 Cine Flash polar distribution; lamp operating at 1 kw, measured at 10 ft with normal diffuser, 18,430 lumens from each lamp.

is pressed a red warning lamp lights up to indicate that the lamp is being overloaded.

The light output from a discharge lamp follows changes in the current through it almost instantaneously. For example when a compact-source lamp operates on alternating current at 50 cycles/sec. the light falls to 4% of the maximum at the end of each cycle. In order to prevent cyclic changes in exposure of the film it is therefore necessary to operate the lamp on a smoothed d-c supply and the ripple voltage should preferably not exceed 10% of the supply voltage.

The control unit is designed normally for operation from a 200- to 250-v d-c supply. When no d-c supply mains are available, the equipment must be operated either from a three-phase rectifier unit or from a mobile d-c generator.

Operation of the Equipment

The first type of equipment to be built consisted of a control unit with one lamp head. This equipment was demonstrated at the Royal Photographic Society on January 13, 1949, and subsequently at the British Kinematograph Society. Generally, however, two light sources are necessary for photography to obtain the necessary light distribution and modeling. Later equipment was therefore redesigned to operate two lamps in series with a single control unit thus enabling the light output to be doubled for the same current from the supply.

A mains voltage selector link on a panel at one end of the control unit is provided for setting the equipment for the particular supply voltage which can be read on the panel voltmeter. This ensures that

the lamps will always operate at their correct wattage. The lamps are started by a high-voltage impulse circuit contained in the control unit, the impulse being applied to the lamp through an insulated high-tension cable. The circuit produces a steep-fronted impulse of approximately 15 kv and will reignite the discharge even if the lamp has not cooled down completely so that inconveniently long delays usually associated with high-pressure mercury vapor lamps are reduced. The arc is ignited by opening and closing a spring-loaded striking switch on the control unit. This switch discharges a condenser through the primary of the pulse transformer and produces a high-voltage high-frequency impulse across the secondary winding. A high-frequency choke in series with one of the lamps and mounted in the lamp housing prevents the impulse from being short circuited by the low-impedance path through the supply mains.

Immediately the lamps strike, the lamp voltage indicated on the voltmeter falls to approximately 20 v and as they warm up the lamp voltage rises. When the total lamp voltage reaches approximately 100 v the starting resistance which limits the starting current should be short circuited by throwing the starting switch over to the "Run" position. After this the lamps will rapidly reach their final operating condition. Interlocking of the starting and striking switches prevents accidental striking of the lamp if the starting switch is in the "Run" instead of the "Start" position. The run-up process takes approximately 10 min.

The lamps are operated normally at 1000 w with a series ballast resistance. To flash the lamps a section of the resistance is short circuited by a contactor, the duration of the flash being predetermined by a resistance-condenser timing circuit. Selector switches controlling the power and duration of the flash are interlocked to give flashes of 3 kw for 5 sec, 5 kw for 2 sec or 10 kw for 1 sec, as required. The duration of the flash and the power in it are limited by temperature considerations; at 5 and 10 kw, melting of the electrodes is the limiting feature while at 3 kw the limit is set by heating of the quartz bulb. After the lamps have been flashed, an interval of at least 30 sec must elapse before they are flashed again, in order to prevent damage due to overheating. This interval is provided automatically by a timing circuit which must be reset manually by a push button before the lamp can be flashed a second time. This circuit cannot be reset until the necessary 30-sec interval has elapsed.

The desirability of preheating the lamps before taking a color photograph has already been mentioned. This is done by pressing the "Preheat" button in the control unit. Part of the ballast resist-

TABLE I. Characteristics of 1–10-kw Pulse Compact-Source Lamp

Over-all length	245 mm
Bulb diameter	45 mm
Arc length	6 mm
Lamp wattage	1, 3, 5, 10 kw
Lamp current, approximate	15, 40, 70, 125 amp
Lamp voltage, approximate	70 v

TABLE II. Illumination and Spot Size Given by Cine Flash

	Normal Glass		Glass Giving Wider Divergence	
Dist., ft	Illum. at center of spot, ft-c	Dia. of spot to 70% of max., in.	Illum. at center of spot, ft-c	Dia. of spot to 70% of max., in.
4	150,000	10	16,500	33
5	100,000	11	11,250	36
6	73,500	12	8,100	40
8	41,000	13	4,500	46
10	30,800	15	3,370	50
12	19,800	17	2,180	56
15	11,700	23	1,290	76
20	6,100	24	665	79
30	2,700	32	300	106

The above figures show the illumination and area covered by each lamp at various distances at 10 kw. The illumination at other wattages may be taken as proportional to the wattage.

ance is thereby short circuited and the required overload is applied to the lamps for 30 sec during which time the bulbs reach the correct temperature and the color stabilizes. The lamps should then be flashed within the next 30 sec; if they are not flashed within that time the preheating procedure should be repeated to offset the cooling which has occurred during the waiting period. Preheating is not necessary for black-and-white photography.

The flashing circuit can be operated either by a push button on the control unit or from an external switch connected by flexible leads to a socket in parallel with this push button. Momentary closure by a microswitch will operate the equipment and the flash can be initiated by a normal built-in camera switch such as that used on the Eastman high-speed camera. The time required to initiate the flash is limited chiefly by the speed of closing of the contactor; it is only a few milliseconds. Two sockets in parallel on the control panel enable several units to be flashed synchronously from the same switch if desired.

In normal operation at 1000 w, the lamp current is 15 amp. When

TABLE III. Light Output From Cine Flash Unit

	Light intensity at center of 12-in. circle at 4 ft from unit, ft-c	Flash duration, sec	Supply Current 230-v, d-c, amp	440-v, 3-ph., a-c, amp per ph.
Cine Flash				
At 1-kw rating	15,000	Continuous	15	5
At 3-kw	45,000	5	40	15
At 5-kw	75,000	2	70	25
At 10-kw	150,000	1	125	45
M-R 414, 5-kw Incan. Studio Spotlight	7,500	Continuous	22	

The figures above give the light output from each lamp with the normal diffusing glass. The values can be doubled if the spots from the two lamps are arranged to overlap one another.

the lamp is flashed at 10, 5 and 3 kw, the respective values of the current are 125, 70 and 40 amp, with corresponding durations of 1, 2 and 5 sec. Although the peak operating current of the equipment is very high, the duration of the surge is quite short. Even so, there may sometimes be a difficulty in providing these high peak currents in locations where the power supply is limited and it is therefore necessary before using the equipment to check that the supply mains are fused adequately.

Owing to the high light intensity given by this unit, exposure is best judged by making practical tests with the lamp at various distances from the subject. Once the correct exposure for a certain distance has been found there will be no difficulty in repeating the results. With the normal setting of the lamp the light intensity at the center of a 10-in. spot at 4 ft from the unit is approximately 15,000 ft-c at 1 kw, 45,000 ft-c at 3 kw, 75,000 ft-c at 5 kw and 150,000 ft-c at 10 kw. The exposure may also be measured with a meter with the lamp operating steadily at 1 kw and then decreased in proportion to the power in the flash.

Table I summarizes the chief optical and electrical characteristics of the lamp. Table II, which shows the light output and size of the spot at various distances from the lamphouse, will be found useful in estimating the exposure at other distances. At maximum power, the light intensity should be sufficient for taking a film at 1500 frames/sec with a fast emulsion and an aperture of $f/11$. With Kodachrome film the unit should give sufficient light when flashed at 10 kw for photography at 3000 frames/sec at a distance of 4 ft with an aperture

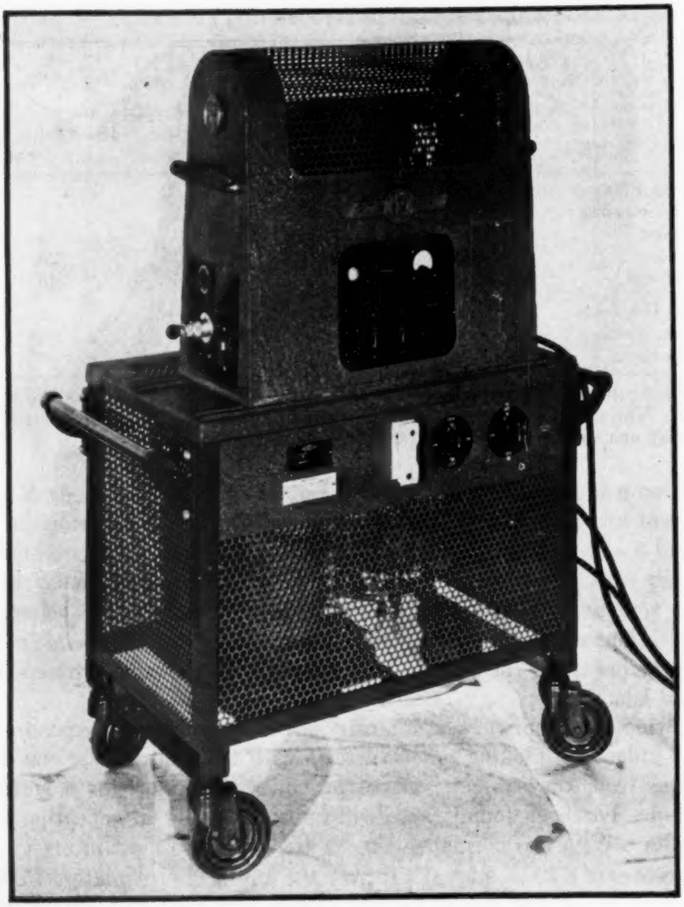

Fig. 6. Rectifier and Cine Flash Unit.

of $f/2.8$. Table III shows the current consumption of the Cine Flash Unit.

For operation from an a-c supply, when no d-c supply is available, a three-phase mercury vapor rectifier has been designed. This is mounted in a mobile framework which is also designed to carry the Cine Flash Unit on top of it. The rectifier and control unit are illustrated in Fig. 6. A smoothing circuit is built into the rectifier unit.

One of the first successful high-speed films made in Kodachrome

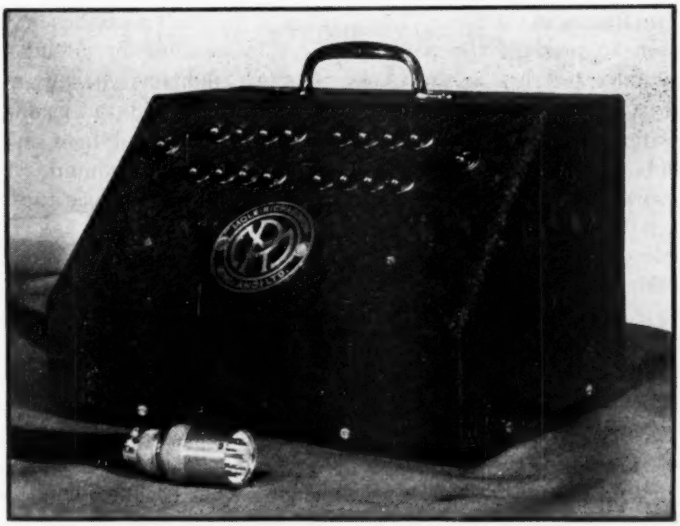

Fig. 7. Control box for lightning effects.

has recently been taken by Kodak Ltd. with the M-R 356 Cine Flash equipment. The subject of this film is the beating of an egg and the fall of a lamp bulb filled with colored paints. The subject was illuminated by three lamps arranged to flash in synchronism when the camera reached full speed. The film was made at 2500 pictures per second with a lens aperture of $f/2.7$. Two lamps were used for front-lighting and one for back-lighting at a distance of 4 ft from the subject.

Equipment of this type will no doubt prove useful in many photographic fields other than those of cinephotography. Scientific applications in which this equipment should find an immediate use include wind tunnel illumination, illumination for Schlieren equipment, projectile photography, underwater photography of projectile explosions or other phenomena. Another application of Cine Flash equipment is in lithographic printing.

The application of this equipment in the film studio appears to be limited to effects lighting as the duration of the flash is far too short for normal cinephotography. For example, the addition of another small control unit shown in Fig. 7 enables the unit to be used for producing artificial lightning or flashing effects for film studio, television or for theaters. This is done by dividing up the duration of the flash into 16 equal intervals, each of which corresponds approximately

to two frames of the film. The number of intervals or flashes may be chosen to produce the required effect by opening or closing any individual switches in the bank. If the equipment is then set to give say, a 10-kw, 1-sec flash, this flash can be broken up to simulate lightning, gun flashes or other effects. The residual light in the standard equipment is approximately $1/10$ of the maximum which is too high to give a good effect on the film. To produce the best effect the residual light can be reduced to approximately $1/50$ of the maximum by inserting an additional resistance to underrun the lamp considerably before the flash is produced. If no residual light whatever is required, a shutter can be used on the front of the lamp which is opened just before flashing the lamp. This method has the advantage that once the nature of the flash desired has been found by trial, the flash may be repeated as often as required.

The original work on the lamp development and its application was carried out in the Research Laboratory, the British Thomson-Houston Co. Ltd., Rugby, by the authors. The practical equipment described in this paper has been developed and built in the Mole-Richardson (England) Ltd. Experimental Dept. The authors wish to make acknowledgments to L. J. Davies, Director of Research, British Thomson-Houston Co., and to Mole-Richardson (England) Ltd. Acknowledgments are also due to the British Thomson-Houston Co. for the photographs which are Figs. 1 and 2.

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A New Heavy-Duty Professional Theater Projector

By HERBERT GRIFFIN

International Projector Corp., Bloomfield, N.J.

SUMMARY: The paper describes the new Simplex X-L 35-mm projector mechanism which is now in production. High lights of the improvements are reduction in mechanical load on the gear train, improved lubrication, new lens mounts, more finger room for threading, a direct viewing telescope focusing device and over-all design simplification.

Driving Mechanism. Figure 1 is a general view of the complete mechanism. The main-drive gear assembly is an extremely simplified vertical unit operated in sealed ball bearings (Fig. 2). This ball bearing construction, which is used throughout, together with the direct high-speed drive, effects a reduction in mechanical load over past practice of approximately 66% at start and approximately 80% while running. Inasmuch as excess mechanical load both at starting and running is the cause of the majority of projector shutdowns this improvement is of particular significance.

The entire driving mechanism and the gear train are housed in an oil-tight enclosure and are visible at all times through a large transparent window which may be easily removed. The wide-face, heavy-duty type of gears are few in number and will require little, if any, attention. All high-speed shafts are equipped with ball bearings, and for added protection both upper and lower sprocket shafts are fitted with Oilite bearings.

Lubrication. Figure 3 shows the Spray-O-Matic lubrication system used. The entire area of this sealed-drive compartment is sprayed continuously by a fine film of oil which reaches every drive unit without allowing a drop to leak through to the film. The oil feed unit is simplicity itself—comprising a high-speed pump, a filter and a pipe. An oil gage fitted with a drainage petcock indicates the oil level. A change of oil is indicated approximately every eight to twelve months.

Intermittent Movement. The intermittent movement has been redesigned and the flywheel has been mounted directly on the camshaft thereby eliminating the intermediate gears to give quieter operation and lowered maintenance costs (Fig. 2). The entire movement may be removed from the nonoperating side of the mechanism. In order to assure parallel assembly the cam pin is ground to its close

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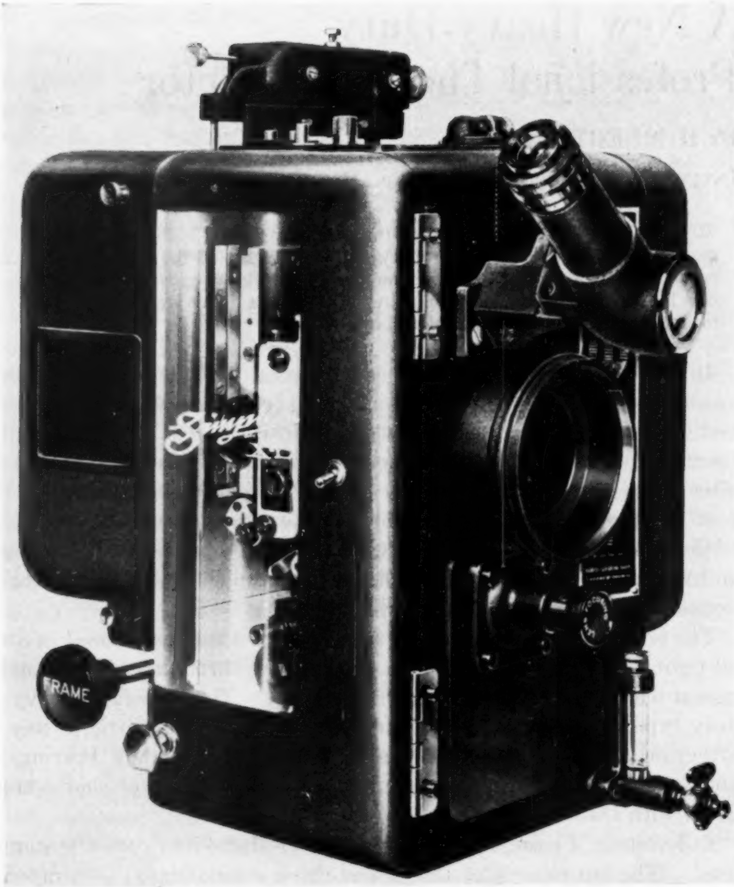

Fig. 1. Complete mechanism of the Simplex X-L 35-Mm Projector.

tolerance after assembly to the cam. The position of the cam pin with relation to the cam ring is slightly adjustable, thus providing simplicity of assembly and replacement.

Continuous lubrication of all parts of the movement is obtained through a separate pump comprising a pair of gears driven from the camshaft which force oil through the intermittent housing.

Shutter. One of the most important design improvements is the new single-cone type of shutter assembly which is located a little more than 1 in. from the aperture, thereby providing an increase in

illumination, compared with the cumbersome front and rear shutter assemblies (Fig. 4). The new shutter is maintained in correct timing by means of a sliding helical spline on the shutter shaft, there being no axial displacement between gears; thus gear noise is greatly reduced. A travel ghost adjustment knob is conveniently located at the top of the main frame.

Framing. The framing device shown in Fig. 2 has convenient handles which protrude from the side of the case and are located so that the picture may be framed from either side.

Lens Mount. Figure 1 shows the new lens mount made to hold accurately new-type lenses up to and including 4 in. in diameter and having speeds as fast as $f/1.6$. This is of particular importance in theaters with long throws and in drive-in theaters when lenses of focal lengths greater than 5 in. are required.

Quick, precise focusing of the lens is simplified by means of the unique Screenoscope device which is essentially an eight-power prismatic telescope mounted above the lens mount (Fig. 1). With the Screenoscope the projectionist may observe a highly magnified section of the screen and accomplish exact focus without eyestrain. As a matter of fact, obtaining a sharp and large focus of the tiny holes in the screen is easily and readily accomplished.

Spot Sight Box. A large eye-protecting viewing glass properly located for easy vision so the projectionist may readily observe the light spot on the film aperture replaces the conventional small spot sight box (Fig. 1).

Change-over. An instant-acting zipper type of change-over unit is part of the mechanism and is mounted above the shutter guard housing as shown in Fig. 1. The dowser blade is positioned between the arc lamp and shutter to protect the shutter blades against warpage and burning.

Threading Compartment. The operating side of the new mechanism is provided with increased "finger room," thus reducing the problem of threading in the film and affording extremely easy operation. A threading lamp lights automatically when the door is opened and additional illumination is provided in the door itself. The readily removable film trap and gate are equipped with long confining film guides and adjustable tension shoes. Means are provided for easily threading in frame by the incorporation of an additional aperture in the upper section of the film trap just below the guide rollers, and an indicator is provided on the outward bearing arm of the intermittent movement to signify when the movement is in the locked position. The interior of the operating side of the mechanism

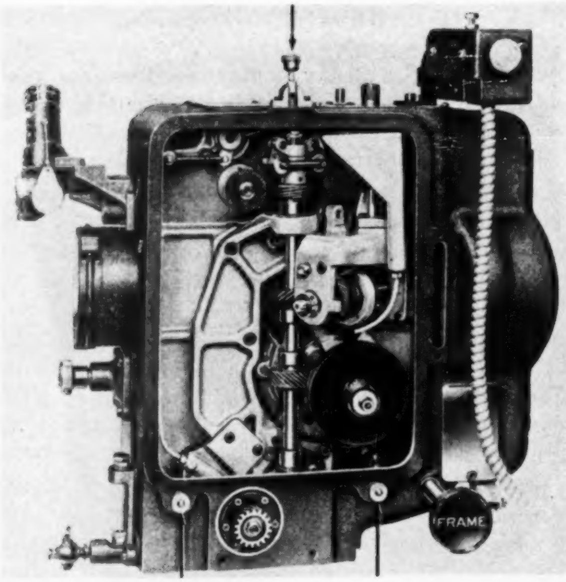

Fig. 2. Main drive assembly.

Fig. 3. Spray-O-Matic lubrication system.

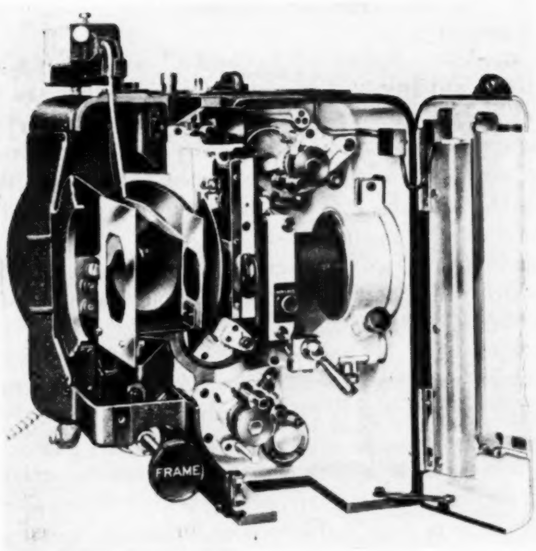

Fig. 4. Shutter assembly.

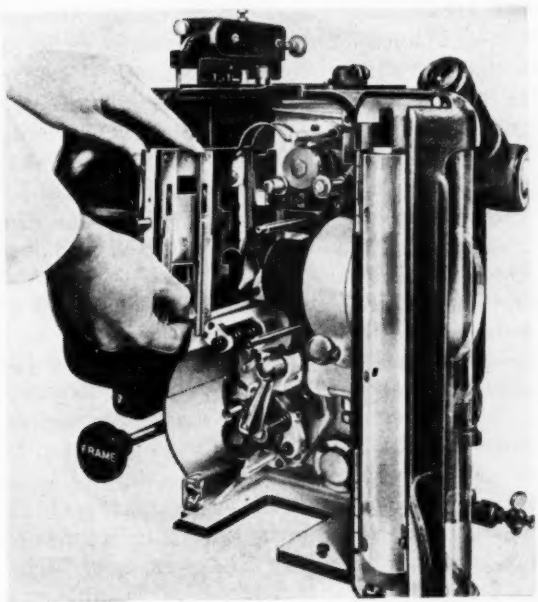

Fig. 5. Automatic safety trip.

is finished in white porcelain enamel and all corners are rounded to eliminate the possibility of dirt accumulation. While the film trap and gate assemblies follow closely the design of the E-7 Simplex mechanism assemblies, improvements have been incorporated which reduce the possibility of heat transference to the aperture plate. The adjustable gate shoe tension has been improved and a push-button gate closing means provided.

Automatic Safety Trip. An improved automatic safety trip is provided which will drop the fire shutter should a patch part above the intermittent sprocket (Fig. 5).

24-Tooth Sprockets. An important new design feature is that both upper and lower sprockets have 24 teeth, 8 more than the conventional type, and they operate at only 240 rpm, a reduction in speed of 33⅓% over ordinary sprockets.

Cooling. Some cooling is obtained for the aperture and film gate by means of air drawn through an opening behind the shutter housing, forced past the film trap and discharged through openings on the operating side of the equipment so that a constant supply of cool air to the film trap is available at all times when the mechanism is in operation.

Upper and Lower Magazines. Both magazines are considerably deeper than usual, to accommodate bent exchange reels. The upper magazine is equipped with an observation lamp and a large porthole so that the remaining footage may be readily observed. Also, a well-designed film valve is provided by means of which, through the addition of a large flanged roller, the film path is maintained in correct alignment with the upper sprocket and scratching of the picture area or sound track is thereby eliminated. The lower magazine is provided with a similar valve and porthole and is also equipped with a newly designed even-tension take-up.

The improvements herein described have culminated a five-year period of designing and tooling-up, plus an exhaustive series of field tests in key circuit theaters operating fourteen hours daily over a span of sixteen months.

A New Deluxe 35-Mm Motion Picture Projector Mechanism

By H. J. BENHAM

Brenkert Light Projection Co., Detroit, Mich.

and R. H. HEACOCK

RCA Victor Div., Radio Corporation of America, Camden, N.J.

SUMMARY: Development of a new deluxe 35-mm motion picture projector mechanism, to be known as the RCA-100, was recently completed and production is now under way. The keynote in the design is high-quality projection continuously over a long period of time without the necessity of costly periodic factory overhauls and replacement of parts. Over ten years of field experience with the Brenkert BX-80 projector mechanism has shown that automatic lubrication, a heavy rugged type of gear train, double rear shutters, unit construction and ease of serviceability are features essential to this objective. These features, together with new additions necessary to meet present-day requirements will be described in this paper.

Automatic Lubrication. In a well-lubricated system there is practically no wear of the metal parts because all contact takes place on films of oil between mating surfaces. In this automatic lubrication system a geared pump inside the housing delivers a continuous flow of filtered oil through a copper tube from the oil reservoir in the base of the mechanism to a rotary lubricator at the top of the gear train. This rotary lubricator is perforated at longitudinal spacings so the various holes are in line with the plane of each gear and bearing in the gear train. In operation, oil is pumped from the reservoir to the rotary lubricator and then showered over all of the parts in the gear compartment, providing lubrication at the right places continuously.

With this method of lubrication filtered oil is circulated throughout the entire gear side of the projector mechanism several times a minute. The heat generated in the intermittent is carried away by the circulating oil instead of remaining confined in the intermittent case. In this manner it also acts as an over-all cooling system in distributing local heat in the gear train throughout the whole mechanism.

Figures 1 and 2 illustrate the advantages of the automatic system over the oilcan or pressure-feed method. All shafts and bearings in the gear train are designed so that they are lubricated continuously

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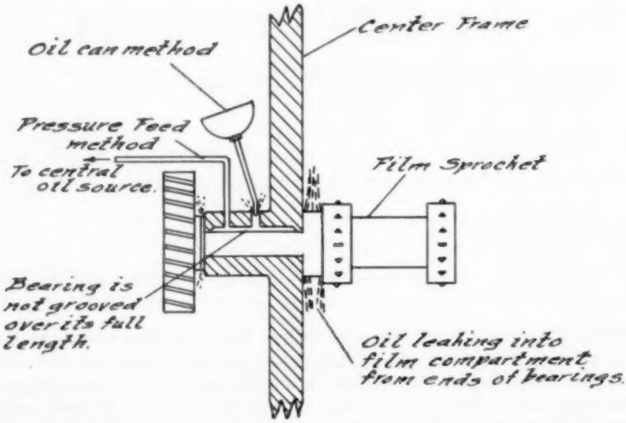


Fig. 1. Pressure-feed and oilcan methods of lubrication.

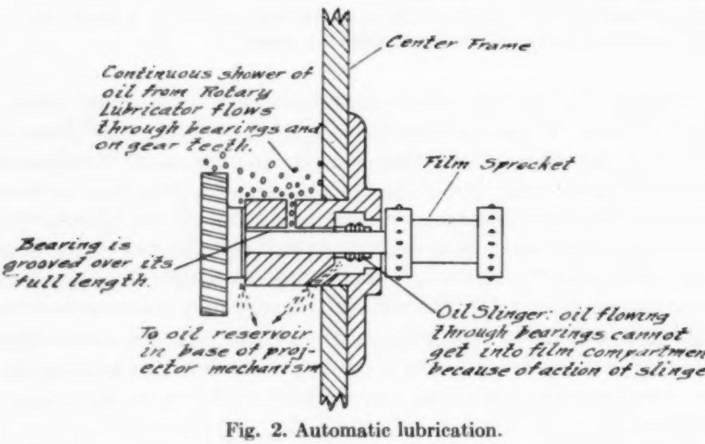


Fig. 2. Automatic lubrication.

over their entire length without any oil leaking from the gear compartment, as shown in Fig. 2.

Gear Train. The gearing in the new projector, shown in Fig. 3, consists entirely of helical gears running on parallel shafts, except for the shutter-shaft drive gears which are spiral bevel gears. This type of gearing can be set up for minimum backlash and with the meshing teeth of mating gears contacting each other over the full width of the gear face. This means smooth and quiet operation and

negligible wear over a long period of time which, of course, means maintaining the original accuracy built into the mechanism.

One of the other factors essential in correct gear design in a motion picture mechanism is to maintain a low gear ratio between the important drive assemblies such as the intermittent, main-drive gear assembly and shutter-drive assembly. This keeps vibration at a low level, and prevents it from traveling through the mechanism where it could increase wear between gear teeth and allow the light shutters

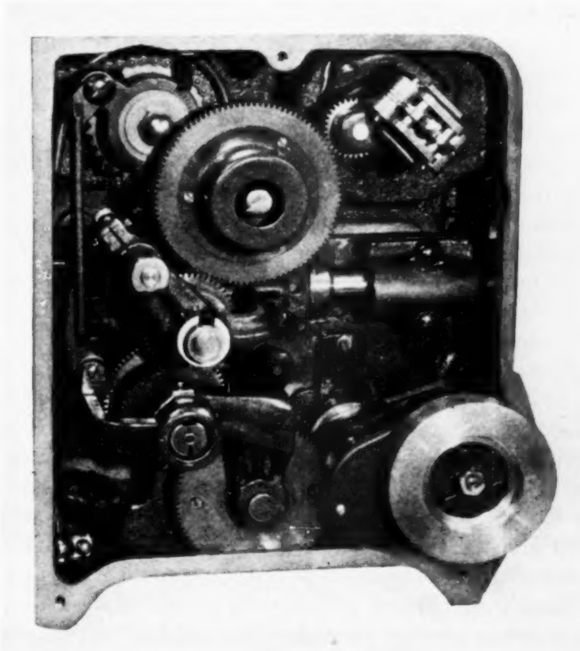


Fig. 3. Gear side of projector (gear cover removed).

to oscillate. Excessive oscillation of the shutters results in inferior projection unless the shutters are widened to compensate for this movement, in which case the efficiency of light transmission would decrease.

From a theoretical standpoint a gear ratio of 1:1 would be optimum for the least amount of wear, quietest operation and minimum vibration. A 1:1 gear ratio is impossible throughout a gear train where shafts rotate at different relative speeds, however, so we have done

the next best thing by using a 2:1 gear ratio between all important drive assemblies.

The light-shutter compensator gear assembly has an important role in the gear train. The purpose of this unit is to enable the picture to be framed at the aperture while at the same time keeping the action of the light shutters in perfect time with the pull-down action of the intermittent, without the use of angular sliding gears. When the framing handle is turned, the radial positions of the shutter drive gears are changed with respect to each other but they always mesh with identically the same teeth in their mating gears, over the same portion of the gear face. With this type of shutter compensator it is not necessary to change the position of the framing knob periodically. The projector will run smoothly and quietly with the framing knob in any position; wear and backlash between gears are eliminated; the same good picture definition and high efficiency of light transmission to the screen obtained originally, is maintained throughout the life of the projector.

Unit construction is used throughout the gear train. All assemblies are accurately located by dowel pins so that perfect alignment is assured without fitting and adjusting for proper backlash. All units are completely interchangeable.

Intermittent Mechanism. The intermittent, together with its star and cam, is shown in Fig. 4. All of the parts are large and heavily constructed. They can thus be manufactured with greater accuracy than could smaller ones and because of this the wear is negligible.

A cross section of the star wheel, shaft, sprocket and bearings is shown in Fig. 5. The star wheel and sprocket shaft are supported for over 60% of the shaft's total length. This long bearing support and the extension of the bearings directly to the star wheel and to the sprocket cause these parts to be held with extreme precision.

Bronze bearings are used throughout the intermittent because they can be manufactured with great accuracy and because of their long wearing qualities. Wear is reduced to a minimum through the use of this type of bearing with a continuous flow of oil through all parts of the intermittent unit.

The index pin on the cam is fitted with a hardened steel roller to eliminate the possibility of flat spots developing on the index pin. This is another instance of precaution which was taken to reduce wear to a minimum.

The intermittent can be removed and replaced in less time than is required to run a reel of film. The sprocket can be removed and replaced in less than one minute.

Film Compartment. The film compartment as shown in Fig. 6 is enclosed by a large glass door with the visible interior illuminated by two concealed lights. This aids in accurate threading of the mechanism and in easy inspection of all operating parts.

The oil gage, which is an integral part of the oil pump, is located

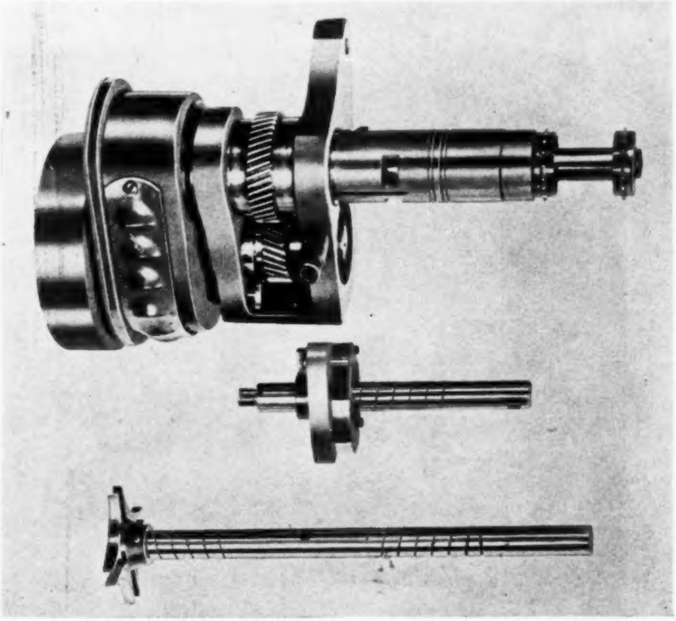


Fig. 4. Intermittent mechanism.

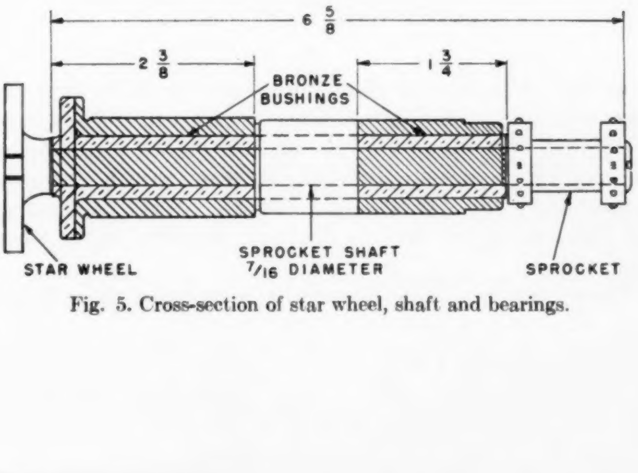


Fig. 5. Cross-section of star wheel, shaft and bearings.

in the lower front corner of the main case. Large entrance and exit oil ports assure correct oil level indications.

Unit construction is used throughout in the film compartment for accuracy and for easy servicing.

Light Intercepting Shutters. The design of the light shutters and associated gearing in a motion picture projector mechanism determine the efficiency of light transmission to the screen. Consistently high,

Fig. 6. Operating side of projector.

efficient light transmission is of great importance in large indoor theaters and in drive-in theaters where pictures up to 70 ft in width are projected. Two rear shutters are used in the projector mechanism rotating in opposite directions so that the light beam is cut simultaneously from the top and bottom. Wide experience has shown that double rear shutters are most desirable for the following reasons:

1. The efficiency of light transmission is increased more than 20%

above that which can be obtained from most projector mechanisms with a single shutter.

2. The light beam is shadowed so that a black, cool aperture is obtained over 12% longer than when one front and one rear light shutter are used.

3. Since the action of the light shutters is to cut the light beam from the top and bottom simultaneously, in a plane removed from

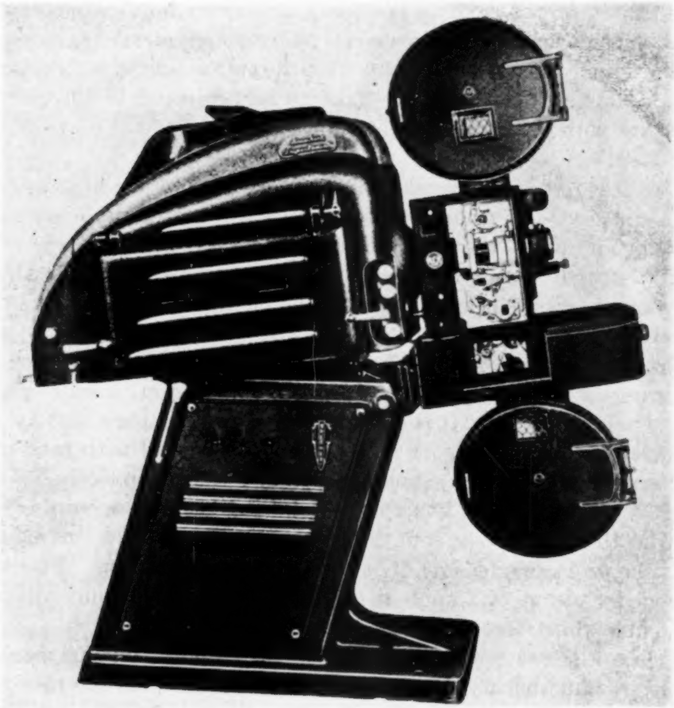


Fig. 7. Complete projector and sound assembly.

the film plane, the intensity of the light on the screen is gradually reduced to zero at the start of the pull-down and then gradually increased from zero to maximum at the end of the pull-down. High efficiency of light transmission can thus be obtained by designing the width of the shutter blades to take advantage of the small movement of film at the beginning and end of the pull-down period without any trace of a travel ghost.

4. From both an operating and an appearance standpoint, it is more desirable for both shutters to be located at the rear of the mechanism than to have one at the front and one at the rear. In those cases where a front shutter is used difficulty is sometimes experienced in removing the lens for cleaning, especially where the mechanism is located close to the front wall.

Heat Baffle. The use of powerful arc lamps in many theaters today makes it essential to baffle all stray light from the metal parts of the film trap to prevent it from becoming excessively hot. A heat baffle is used which consists of three metal plates spaced about $\frac{3}{16}$ in. apart and positioned in a vertical plane with the optical axis in such manner as to allow an $f/2.0$ beam of light to be projected to the picture aperture with a minimum light spill around the metal parts of the film trap.

The heat resulting from stray light intercepted by the heat baffle is carried away by a rotary fan located at the top of the main case, drawing air up past the sections of the baffle.

The entire film trap is completely enclosed with a metal light shield preventing stray light escaping from the picture aperture and shining into the projectionist's eyes.

Projection Lens Mount. The lens mount has been designed to accommodate the new long focal length $f/2.0$ projection lenses which are 4 in. in diameter. It is easily removed as a complete unit by the removal of four screws. A metal collar is provided with each projector mechanism so that standard diameter projection lenses in focal lengths up to 5 in. can be accurately held in this lens mount. Two knurled thumb screws in split rings, one at each end of the lens mount, hold the projection lens rigidly and accurately in position. Focusing is done by means of a knob at the front of the lens mount which is accessible from either side of the mechanism.

Figure 7 shows a complete projector assembly including the new Brenkert Supertensity Arc Lamp in combination with the new projector. This is typical of the units which are now being supplied for deluxe drive-in theaters throughout the country.

68th Convention

RESERVATIONS are coming in to the Lake Placid Club and to the Hotel Marcy, these in response to the Convention Advance Notice which went to all members in mid-August. If you have overlooked yours, ask Society headquarters for the information and make your arrangements without delay.

PAPERS have been scheduled for ten technical sessions; two evenings will be devoted to awards and Banquet; one evening is reserved for prerelease showing of a feature motion picture; and a prerelease feature motion picture will also be shown on one afternoon. Sessions topics, detailed in the Tentative Program being mailed separately, are:

Monday Afternoon	Television
Monday Evening	Award Presentation
Tuesday Morning	Television and TV Film Pictures
Tuesday Afternoon	Television, Sound Recording, Color
Wednesday Morning	Magnetic Recording
Wednesday Afternoon	High-speed Photography
Wednesday Evening	Cocktail Party, Banquet and Dance
Thursday Morning	High-Speed Photography
Thursday Afternoon	Film Registration, Aperture Calibration and Sound Recording
Thursday Evening	Color and Trick Photography
Friday Morning	Sound, Projector Carbon and Theater Television
Friday Afternoon	Theater Television

AT LAKE PLACID, there will be a program with many attractions: some new subjects and some generally familiar ones newly high-lighted; entertainment and recreation of inviting variety.

Engineering Committees Activities

Screen Brightness

The Screen Brightness Committee under Wallace Lozier's Chairmanship is now ready to start the 100-theater screen brightness survey which has been under discussion for the last six months. Actual measurements will begin about mid-September. Task groups responsible for survey work have been set up in Los Angeles, New York, Philadelphia, Chicago, Toledo and Rochester. The first theaters visited will be in the New York area, where it is planned to start with 30 indoor and two outdoor theaters.

The photoelectric instrument developed by Allen Stimson of the General Electric Co. has been checked to assure accurate measurements, and since there is only one in existence the survey will necessarily have to proceed slowly at first. General Electric has agreed, however, to supply instruments for $345 each, providing ten or more can be manufactured at one time. All likely customers are being canvassed, and it is hoped to have before long additional instruments available to survey teams.

Every means possible will be taken by those making the survey to avoid upsetting normal theater operation, and at least 24 hours' notice will be given any house it is proposed to survey. With the exception of about 15 minutes for making actual screen measurements, the remaining data can be gathered during the regular show.

A word of thanks is due the *International Projectionist* for the excellent publicity they have given this project in both their June and July issues. We have every anticipation of a worth-while job being done.

Television

The first regular meeting of the Joint RTMA-SMPTE Committee on Television Film Equipment was held at the Hotel New Yorker on July 18. Their work got off to an excellent start with all of the SMPTE delegates on hand. The primary task at the moment is the completion of a specification for a 16-mm television film projector which originated within RTMA.

While the specification framework has been completed, many of the detail requirements need further study. Approximately a dozen task groups were organized and requested to prepare drafts of various sections for circulation to committee members prior to the next meeting. Standards for picture aperture size to be used in video recording and the area to be scanned in reproduction of opaques and slides were also discussed and recommendations will be made in the near future.

Magnetic Recording

Last April, Glenn Dimmick's subcommittee working on standards for magnetic recording recommended submitting proposed standards for track location on 35-, $17\frac{1}{2}$-, 16- and 8-mm motion picture film to the Sound Committee for its recommendations on publication. The ballot was sent out early in July, but serious objections were received from one of the major studios which felt that the limited experience with the present proposals did not warrant wide circulation in the JOURNAL. Further action will be delayed until this problem is resolved within the Sound Committee.

High-Speed Photography Question Box

Here are answers to five questions on high-speed photographic techniques which appeared on p. 122 of the July JOURNAL. These answers were contributed by: J. H. Waddell of Wollensak Optical Co.; Henry M. Lester, Consultant; Kenneth Shaftan of Burke and James; and Eugene L. Perrine of the Armour Research Foundation.

Further questions and answers will appear in subsequent JOURNALS. If you wish to participate send either your questions or answers to Society Headquarters.

A1. This question concerned taking high-speed motion pictures of moving parts inside a black bakelite device the size of a dime. Speeds of 4,000 to 8,000 frames/sec were required. With methods now being used, insufficient exposure has been obtained when using Super XX film and heat generated by the light source altered performance of the device under test.

One suggested solution was the use of continuous flash lighting units to provide ample light free of heating effects normally encountered with tungsten or arc illumination. Adequate exposure and depth of field can be secured by using two flash units properly placed, and a 2-in. lens with a suitable extension tube at effective apertures ranging from $f/6.3$ to $f/9$.

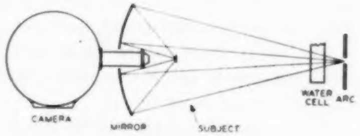


Figure A-1.

A second solution is proposed in Figure A-1. In this method the center was cut

out of a 12-in. diameter parabolic mirror of 6-in. focal length so that it could slip over the lens and extension tube of the camera. Precision quality Bausch & Lomb parabolic mirror has been used. Elliptical mirrors are better suited for this application when photographing extremely small areas, but where sharp focus of the light beam is not required the paraboloid is satisfactory. A small, hand-fed carbon arc using from 5 to 10 amp is used about 2 ft behind the subject, and the mirror adjusted so that the arc is focused on the area to be photographed. A water cell for removing the heat is placed in the beam close to the arc so that all light falling on the mirror passes through the cell. The proponent of this method states that sufficient illumination is obtained for magnification on the film of up to five times at a speed of 5000 frames/sec.

A third proposed solution uses a plane mirror with an elliptical hole large enough to accept the camera lens. The mirror is placed at an angle of 45° to the optical axis so that the light is reflected from the mirror to the subject. A partial reflection transmission mirror could be used instead, but that would reduce the exposure by a factor of approximately 50%, and only half the light would reach the subject. Satisfactory mirrors of this type may be secured from Evaporated Films, Inc., Ithaca, N.Y. It is also recommended that long focus lenses with extension tubes be used to secure adequate distance between the subject and the camera. If a water cell is used, as described on p. 450 in the article "High-Speed Photography" in the November 1949 JOURNAL, heat can be reduced to a negligible amount. It is also suggested that a G.E. 750-R lamp or a Rosslite of similar characteristics be employed. Distance from lamp to mirror to subject should be approximately 15 in. for maximum illumination. In making high-speed pictures of this type, a suitable exposure meter should always be used.

A2. The second question concerned high-speed motion pictures of small parts of a mechanical device moving at 15 to 30 cycles/sec. A Fastax camera is employed at a frame rate of 1250 frames/sec, with a 6-in. lens, an object distance of 8 ft, Super XX reversal film, and two 750-w reflector spot lamps. Since all surfaces had similar finish, it was extremely difficult to distinguish between adjacent parts in the projected picture.

The first reply to this question suggested very diffuse lighting through use of a translucent tent between light and subject. It was pointed out that this would obviously result in a considerable loss of light, but with continuous flash lighting units this loss could be tolerated. By appropriate arrangement of the tent and choice of material, however, loss of light can be held to a minimum.

A second answer stated that if the light source is placed correctly, there should not be too much trouble from specular reflections when the exposure factor is correct. Bad flare is produced from machined parts when there is definite over-exposure in a high speed camera. If the exposure is somewhat reduced, brightness of parts, even though made of brightly polished metal, should be easily controlled. The light source must be as near the camera as possible, and either G.E. Electric 750-R or Rosslite lamps should be used.

A3. Question 3 dealt with photographing vibration effect on various components of air-borne instruments. These instruments are extremely small and encased, making it necessary to illuminate and photograph through a hole in the cover. Vibration frequencies of 800 cycles/sec, with object motion as little as 0.001 in. are encountered.

The first reply pointed out that it is possible to photograph and illuminate through a hole in the cover of an encased instrument by high-speed photography only if the hole is large enough. The smallest hole believed to be feasible is about 5 in. in diameter. It was stated, however, that a somewhat smaller hole might be used with variations in technique.

The first method suggested was to direct the light output of a continuous flash lighting unit on a spherical mirror with a hole in the center for the camera lens. A second method was to surround the camera lens with an electronic flash tube, discharging its light output in synchronism with the high-speed camera shutter. It was pointed out that Dr.

Harold Edgerton of M.I.T. has designed an electronic flash lamp capable of doing this job. For conditions outlined in this question, it was suggested an Eastman Type 3 camera be used at frame rates of 3000 frames/sec. A movement of 0.001 in. could then be magnified about 200 times both in time and space, offering an adequate record, either on the screen or in still picture enlargements of single frames.

Another reply suggested use of a Fastax camera with auxiliary control equipment to secure 14,000 pictures/sec. Frame rates of this order are necessary for studying frequencies as high as 800 cycles/sec. It was also suggested that in studying vibrations of extremely small excursion extension tubes be used on camera lenses, and the pictures be projected at about a magnification of 100. Magnification of 100 times of a 0.001-in. excursion will then appear on the screen as 0.1 in. For lighting, a G.E. 750-R lamp should be used, so placed that the plane of vibration is clearly emphasized with respect to the stationary surrounding subject. At least two lamps should be used in this setup with a high-low series-parallel switch in order to focus the camera with lamps in series and expose with lamps in parallel.

A4. This question dealt with photographing a 3 × 5 ft area of a dark machine at a frame rate of 3000/sec. Here again inadequate exposure was being obtained, and high amperage power lines were not available.

The first reply stated that successful results had been obtained under similar conditions, using continuous flash lighting units on dark areas of up to 4 sq ft In this case, also, the machine being photographed was black. The frame rate was 3000/sec, with the lens set at $f/4$. Using Super XX film, a satisfactory record was attained. This type of lighting requires much less power than incandescent units.

A second reply suggests use of sunlight for illumination. If the equipment photographed is extremely dark, it may be necessary to use booster mirrors to light adequately the whole surface. Frame rates of 3000/sec are entirely possible in direct sunlight, but not behind windows.

A5. This question dealt with special processing for reversal film used in high-speed photography. The first reply named two manufacturers of processing equipment suitable for this type of work: Micro Record Corp., New York City; and Morse Instrument Co., Hudson, Ohio. It was pointed out, however, that while machines made by either of these companies could do a job of controlled processing, in both cases the task is tedious and far from satisfactory when a quantity of film is involved. Both require special drying facilities and great care in handling of films with black coatings. It was believed that the advantages of longer first development are questionable unless the additional development is accurately timed and definitely related to the degree of underexposure. Faster film such as Kodak's Linagraph (negative stock is 50% to 60% faster than Super XX reversal) might be used, and is simpler to process on the two units mentioned above. The best answer is to avoid working near the borderline of underexposure, which always results in pictures lacking in detail, definition, contrast and depth.

Another reply suggested referring this problem to the Houston Corp. in Los Angeles which builds special 16-mm processing equipment.

Journals Out of Stock: The Society's stock of JOURNAL issues for March, Part II, July, August and September, 1949, has been exhausted as a result of an unexpected increase in demand and the Society's Headquarters is anxious to purchase a stock of each. Members or libraries having extra copies available are invited to send them in. The going price is 75c.

Book Reviews

The American Annual of Photography, Volume 64, 1950. Edited by Frank R. Fraprie and Franklin I. Jordan

Published (1949) by the American Photographic Publishing Company, St. Paul, Minn. 208 pp. incl. 120 illus. + 38 pp. Who's Who + 30 pp. Advt. Paper bound, 7 × 10 in. Price, $2.00.

This 1950 issue (Volume 64), I feel, surpasses all previous issues. Articles such as "The Work of Jose Ortiz-Echagüe" are entertaining and inspiring, especially when so splendidly illustrated. Other articles are equally well written and illustrated. Such articles as "Printing Exposure Determination by Photoelectric Methods" and "The Physiology of Film Base" will probably appeal more to our technically minded SMPTE members but such articles as "The Motion Picture Camera in Science and Industry," "The Camera as a Field Research Tool," "Photography in Industry and Science," "The Work of Eadweard Muybridge," in fact all of the sixteen diversified articles will appeal to anyone interested in the progress of photography, pictorial and otherwise.

There are some 67 full-page pictorial illustrations of an international nature which are intelligently described and analyzed by Frank R. Fraprie.

The Who's Who in Pictorial and Color Photography as well as the exhibition records for the past three years will be of special interest to those who are concerned with salon exhibition.—John W. Boyle, 139½ S. Doheny Drive, Los Angeles 48, Calif.

Practical Television Engineering, by Scott Helt

Published (1950) by Murray Hill Books, Inc. (A subsidiary of Rinehart and Co.), 232 Madison Ave., New York 16, N.Y. xv, 708 pp., including 30 pp. glossary, 14 pp. index, 387 illus. and numerous tables. 6 × 9 in. Price, $7.50.

Mr. Helt's book is a significant contribution to the television-engineer-to-be. With the lifting of the freeze, the rush to install more television stations will be on in full force. Many electronics engineers will be faced for the first time with the day-to-day television operating problems. It appears that Mr. Helt was aiming toward that group particularly. They will find this book extremely helpful.

There is a certain unevenness in the density of theoretical treatment. Upon analysis, it becomes evident that this is just what Mr. Helt intended. For example, the section on studio lighting is right to the point with details of the type of lights to use and how to place them. Yet the theory of the image orthicon is covered in simple straight-forward language minus equations. This makes good sense because no operating engineer is going to design an image orthicon. He has only to recognize its operating characteristics and decide whether or not a tube should be used or rejected. Yet with lighting he can be a "designer" and with this book he has sufficient information to deal intelligently with the problem without reference to any other source material.

The discussion of lens theory is well handled and the bridge to electron optics skillfully presented. The advanced reader is naturally led to more rigorous texts on electron optics.

The importance of the cathode-ray tube oscilloscope to the television engineer cannot be overemphasized. Mr. Helt wisely goes into great detail to explain its operation and use. This chapter alone will make this book very important. He also gives interesting manufacturing information on cathode-ray tubes which provides the new television engineer with some useful background.

The chapter devoted to the synchronizing generator is quite complete. The theory and design concepts are well presented, particularly where they will provide a better understanding necessary to good maintenance technique. The succeeding chapters deal competently with video amplifiers and associated compensating circuits, power supplies and the receiver.

Mr. Helt makes a successful effort to provide the operating television broadcast engineer with a good understanding of the receiver. Too often, engineers overspecialize to a point where the station man has little understanding of the receiver man's problem. Yet no television system is complete without the home receiver.

With regard to the transmitter, more detailed information may be required. The author favors the studio engineer by providing helpful hints on approved maintenance procedures and best studio practice. The book is already long, nearly 700 pages.

Mr. Helt has succeeded in authoring a book which was greatly needed. He has accomplished his task with a professional quality. This book is fully recommended to the industry as a practical exposition of the engineering problems in television broadcasting.—E. ARTHUR HUNGERFORD, JR., General Precision Laboratory, Pleasantville, N.Y.

Sound Absorbing Materials, by C. Zwikker and C. W. Kosten

Published (1949) by Elsevier Publishing Co., 215 Fourth Ave., New York 3. 171 pages + 3 pp. index. 92 illus. 9½ × 6½ in. Price, $3.00.

The first-named author was formerly Professor of Physics at Delft Technical University, Netherlands, and is now connected with Philips Electrical Industries, Eindhoven. The second is Lecturer of Physics at Delft Technical University. Their book is essentially an account of the theoretical and experimental work done by them and by other European investigators, with some references to American sources, in developing along basic scientific lines the relation of the sound absorbing properties of materials to measureable physical characteristics of their composition and structure. The first chapter treats the use of acoustic impedance as a valuable intermediate step in this relation. In later sections the wave equations and impedance characteristics are derived for several types of absorbing media: an air impervious compressible material with internal friction (sponge rubber), a porous material with an elastic frame (felt or mineral wool blanket), and a porous material with a relatively rigid frame, as exemplified by some of the common types of commercial acoustical materials. Methods of measurement of the material constants governing impedance, such as air-flow resistance, porosity (percent of voids), and compression modulus of the material structure are discussed. Measurement of impedance and normal incidence coefficients of small samples is covered in some detail, and typical experimental results are given.

Absorption by resonators is treated extensively. These include the simple Helmholtz resonator consisting of an air cavity with a small orifice and combinations of such resonators having staggered frequency responses. Practical constructions of this type have been used successfully in Europe for room acoustical correction. The basic resonator theory is extended to the more familiar case of a perforated rigid board over an air space which may be completely or partially filled with porous absorbing material. Useful design formulae and charts are included for the various cases. It is rather surprising that no mention is made of absorption by diaphragmatic vibration, which is utilized in the familiar curved plywood studio treatments and in at least one commercial material. Another

distinct type of absorber is the integrally perforated porous material. This is very widely used, but is touched on only briefly in the book, and no attempt is made to develop an adequate theory for this case.

In the final chapter, methods of absorption measurement at angles of incidence other than normal are briefly mentioned, and the difficulties in predicting absorption characteristics under random incidence or room conditions from normal incidence data are pointed out.—HALE J. SABINE, The Celotex Corp., Chicago 3, Ill.

American Cinematographer Hand Book and Reference Guide Seventh Edition, by Jackson J. Rose

Published (1950) by American Cinematographer Hand Book, 1165 North Berendo St., Hollywood 27, Calif. 299 pp., 3 pp. index, 85 tables, 10 photographs in color + 38 pp. advt. $6^1/_2 \times 4$ in. Flexible binding. Price, $5.00.

The Seventh Edition of this convenient pocket size hand book and reference guide has been expanded to 325 pages. It still contains the charts, formulas and technical information which professional cinematographers have been using for years but the book has been brought up to date with the addition of latest information on the various color processes: Technicolor, Monopack, Ansco, Kodachrome, Du Pont, Ektachrome, Bipack, Trucolor, etc. The new method of "Latensification" is explained as well as many of the newer gadgets being used in the professional field today. The color illustrations are extremely helpful in showing various "filter" results in monochrome. Magnetic recording, television photography and "T" stops are a few of the newer subjects. The author and compiler, Jackson J. Rose, A.S.C., has had the cooperation of his colleagues in the film industry and has been quick to use their suggestions for improving cinematography and finding a simpler way to achieve artistic photographic results.—JOHN W. BOYLE, $139^1/_2$ S. Doheny Drive, Los Angeles, 48, Calif.

Theatre Catalog, 8th Annual Edition, 1949-1950

Published (1950) by Jay Emanuel Publications, Inc., 1225 Vine St., Philadelphia 7. 1-528 pp. + i-x, profusely illus., includes advtg. $9\frac{1}{4} \times 12\frac{1}{4}$ in. Price $5.00 (foreign shipments $10.00 a copy).

This new *Theatre Catalogue* isn't the type of publication that motion picture and television engineers would normally read. It is, nevertheless, an impartial picture of motion picture operation and design, covering almost every phase of a fascinating business.

The engineer's interest in this great industry cannot properly be limited to his laboratory. Auditorium design is changing constantly and with it new problems confront the alerted engineer. Panoramic viewing conditions approaching the normal viewing conditions of the human eye are desirable, yet little has been done about it. Drive-in theaters are here to stay and so is theater television. Third dimension projection is a stimulus that theaters need badly. What is being done about it today?

The *Theatre Catalogue* not only discusses certain phases of projection and sound but dwells on design and construction, maintenance and management. The engineer must be familiar with these phases of the business, otherwise he cannot properly tackle theater operation problems.

Attention is directed, for instance, to the section on theater design and to the section on new equipment. Know well the ultimate use of equipment so carefully designed in the laboratory. Where and under what conditions will the finished motion picture be viewed by John Public? How can improvements be made in the over-all result? How can picture presentation be vitalized? What changes can be made to better a system of projection now essentially 23 years old?

The *Theatre Catalogue* is not primarily reading matter for an engineer—but it should be. By completely understanding a vast operation it is hoped that the motion picture and television engineers will: (1) see the inadequacy of current practices so that they may be improved; (2) publish the results of their findings freely so that others may develop the germ of an idea; (3) realize that they are likely to play as important a part as anyone else in this business' future; and (4) believe that their ideas are good as far as they go but that they do not go far enough.—Leonard Satz, Raytone Screen Corp., 165 Clermont Ave., Brooklyn, N.Y.

Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer
vol. 31, no. 5, May 1950
Pushbutton Zoom Lens for TV (p. 160) H. I. Smith
Adapting Motion Picture Lighting to Television (p. 162) L. Allen

vol. 31, no. 6, June 1950
The Infra-Red Photographer Evaluator (p. 196) S. Horsley
Matching Location Footage with Studio Shots (p. 197) H. A. Lightman
Optical Effects with Any Camera (p. 198) I. Browning
When and How to Use Camera Angles (p. 201) P. Tannura
Britons First With Tape Sound Unit for Silent Home Movie Projector (p. 204)
Ansco Announces New 16-mm Color Duplicating Film (p. 205)

Audio Engineering
vol. 34, no. 6, June 1950
The Columbia Hot Stylus Recording Technique (p. 11) W. S. Bachman
An Adventure in Loudspeaker Design (p. 14) H. T. Souther
Considerations in the Design of Feedback Amplifiers (p. 17) H. I. Keroes

International Photographer
vol. 22, no. 5, May 1950
Are Cameramen Necessary on TV? (p. 5) H. Birch
The Camera Optical Engineer (p. 8) R. L. Greene

International Projectionist
vol. 25, no. 5, May 1950
Notes on Modern Projector Design (p. 14) R. A. Mitchell

vol. 25, no. 6, June 1950
Notes on Modern Projector Design, Pt. II (p. 7) R. A. Mitchell
Heat, Light Reflectivity is Upped by Kodak Mirror (p. 11)
An Optical Alignment Check System (p. 17) C. W. Handley
New Simplex Sound System Shown by IPC (p. 23)
U. S. Navy 16-mm Projection Specs (p. 26) J. J. McCormick

Motion Picture Herald
vol. 180, no. 1, July 1, 1950
Safety Stock is Now 85% in Use by Trade (p. 13)

Radio & Television News
vol. 43, no. 6, June 1950
RCA's New Direct-view Tri-color Kinescopes (p. 46)

Tele-Tech
vol. 9, no. 7, July 1950
Experimental Tri-Color Cathode Ray Tube (p. 34) C. S. Szegho
Process Screen Projection, Pt. I (p. 39) R. A. Lynn and E. P. Bertero

New Members

The following have been added to the Society's rolls since the list published last month. The designations of grades are the same as those in the 1950 MEMBERSHIP DIRECTORY:
Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

Baumhofer, Hermine M., Archivist, Wright-Patterson Air Force Base. **Mail:** 532 Telford Ave., Dayton 9, Ohio. **(A)**

Cleveland, H. W., Physicist, Eastman Kodak Co. **Mail:** 1669 Lake Ave., Rochester, N.Y. **(A)**

Crose, Harold G., Motion Picture Projectionist, Lyric & Rialto Theatres. **Mail:** 855 S. 20th East St., Salt Lake City, Utah. **(A)**

Del Porte, Earle N., Projection Supervisor, Station KSD-TV. **Mail:** 445 Alice Ave., Kirkwood 22, Mo. **(A)**

Downes, L. C., Designer, TV Film Projection Equipment, General Electric Co. **Mail:** 947 James St., Syracuse, N.Y. **(A)**

Duggan, Robert, Owner, The Studio Lighting Co., 1548 N. Dearborn, Chicago, Ill. **(A)**

Fallon, Louis F., Sales Representative, Ampro Corp. **Mail:** 985 Franklin Turnpike, Allendale, N. J. **(A)**

Fulgham, Claude O., Vice-President in Charge of Management, Video Theatres. **Mai** 1 $11^1/_2$ N. Lee, Box 1334, Oklahoma City, Okla. **(A)**

Julin, Kurt, Technical Chief, A. B. Cosmorama. **Mail:** Skillnadsgatan 60A, Gothenburg, Sweden. **(M)**

Kinstler, Richard C., Head, Photographic Laboratory. Procter & Gamble Co., M. A. & R. Bldg., Cincinnati 17, Ohio. **(M)**

Lepore, Alfred Louis, Electro-Acoustic Engineer and Cameraman. **Mail:** 732 and 736 Manton Ave., Providence 9, R.I. **(M)**

Nemeth, Ted, Motion Picture Producer, Director and Cameraman, Ted Nemeth Studios, 729 Seventh Ave., New York 19. **(M)**

Parker, Will A., Motion Picture and Television Consultant, Film Counselors, Inc. **Mail:** 60 Manursing Ave., Rye, N.Y. **(A)**

Potts, Clifford F., Motion Picture Producer, Fordel Film Laboratories, 1187 University Ave., Bronx 52, N.Y. **(M)**

Rivera, Joseph V., General Motion Picture Laboratory work and Dupe Printer, Circle Film Laboratory. **Mail:** 873 E. 162 St., Bronx 59, N.Y. **(A)**

Saunders, James Arthur, Assistant Engineer, Western Australian Government. **Mail:** 257 Crawford Rd., Inglewood, Western Australia. **(A)**

Shagin, Ralph J., Photographic Merchandising Analyst. **Mail:** 686 Kent Ave., Teaneck, N.J. **(M)**

Temple, Dwight Irving, Television Engineer, Technical Supervisor, Columbia Broadcasting System, Inc. **Mail:** 47 Lockwood Ave., New Rochelle, N.Y. **(A)**

Watson, Lloyd E., Research Chemist, Technicolor Motion Picture Corp. **Mail:** 1708 Scott Rd., Burbank, Calif. **(A)**

Willoughby, Anthony Haydn, Consultant Electrical Engineer, Sir Robert Watson-Watt & Partners, Ltd. **Mail:** 7 Gayfere St., Westminster, London, England. **(A)**

CHANGE OF GRADE

Anderson, James A., Assistant Production Manager, Alexander Film Co., Colorado Springs, Colo. **(A) to (M)**

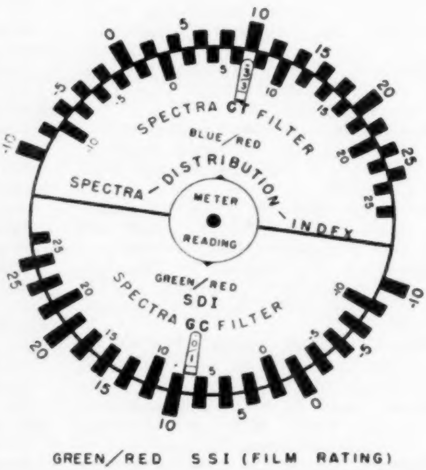
Churko, John G., Sales Engineer, Century Lighting Co., Inc. **Mail:** 106 E. 108 St., New York 29, N. Y. **(S) to (A)**

Williams, Paul A., Audio-Video Engineer, KPIX, Inc. **Mail:** 341 Hazelwood Ave., San Francisco 12, Calif. **(A) to (M)**

SMPTE Officers and Committees: The roster of Society Officers was published in the May JOURNAL. The Committee Chairmen and Members were shown in the April JOURNAL, pp. 515–22; changes in the Engineers Committees have been extensive and so the complete rosters are given on pp. 337–40 of this JOURNAL.

New Products

Further information concerning the material described below can be obtained by writing direct to the manufacturers. As in the case of technical papers, publication of these news items does not constitute endorsement of the manufacturer's statements nor of his products.



The Spectra Three-Color Meter is a new instrument recently announced by Photo Research Corp., Burbank, Calif., succeeding the firm's Spectra color temperature meter widely used in motion picture color photography.

Designers of the new instrument have spent several years developing a system which would relate the amounts of red, green and blue in an illuminant to the color balance of different types of color film and to the selection of any necessary corrective filters. The result is a log index derived from the ratios of blue to red and of green to red. The Spectra Index for photoflood lamps is 2.0/1.0 which means that a photoflood lamp emitting light of the color for which Type A color film is balanced will give a reading of 2.0 on the blue-red scale of the meter, and of 1.0 on the green-red scale.

If the B-R reading is more than one unit high or low, a correction filter of the turquoise-salmon series must be applied. If the G-R reading is more than half a unit away from the correct value, a correction filter of the green-magenta series must be placed over the lens. In either case, a computer (right, above) indicates directly the filter to employ. A card is furnished indicating the Spectra Index ratings of available color film materials.

To facilitate the use of the three-color system, the firm is also making a complete series of mounted glass filters to match the scales of the Three-Color Spectra. One series of filters, the *CT*, provide the usual type of correction for yellowish or bluish light. The new series, the *GC*, correct for a deficiency or excess of green in the illuminant.

In addition to supplying the new meter, Photo Research Corp. reports that it will convert any of the older two-color meters to the new model, at a reasonable charge, the shape and general construction of the instrument having been kept the same.

Society Engineering Committees

As of August 15, 1950

CINEMATOGRAPHY. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture cameras, accessory equipment, studio and outdoor-set lighting arrangements, camera technique and the varied uses of motion picture negative films for general photography.* (*File 5*)

C. G. Clarke, *Chairman*, 20th Century-Fox Film Corp., Beverly Hills, Calif.

(*Under organization*)

COLOR. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of color motion picture processes, accessory equipment, studio lighting, selection of studio set colors, color cameras, color motion picture films, and general color photography.* (*File 10*)

H. H. Duerr, *Chairman*, Ansco, Binghamton, N.Y.

R. H. Bingham
M. R. Boyer
H. E. Bragg
O. O. Ceccarini
R. O. Drew
A. A. Duryea
R. M. Evans
J. G. Frayne
L. T. Goldsmith
A. M. Gundelfinger
W. W. Lozier
A. J. Miller
C. F. J. Overhage
W. E. Pohl
G. F. Rackett
L. E. Varden

FILM DIMENSIONS. *To make recommendations and prepare specifications on those film dimensions which affect performance and interchangeability, and to investigate new methods of cutting and perforating motion picture film in addition to the study of its physical properties.* (*File 15*)

E. K. Carver, *Chairman*, Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.

E. A. Bertram
A. F. Edouart
A. M. Gundelfinger
W. G. Hill
A. J. Miller
W. E. Pohl
N. L. Simmons
M. G. Townsley
William Wade
Fred Waller
D. R. White

FILM-PROJECTION PRACTICE. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture projection equipment, projection rooms, film-storage facilities, stage arrangement, screen dimensions and placement, and maintenance of loudspeakers to improve the quality of reproduced sound and the quality of the projected picture in the theater.* (*File 20*)

L. W. Davee, *Chairman*, Century Projector Corp., 729 Seventh Ave., New York 19

C. S. Ashcraft
Frank Cahill
R. H. Heacock
C. F. Horstman
G. T. Lorance
H. T. Matthews
Paul Ries
Harry Rubin
Ben Schlanger
J. W. Servies

HIGH-SPEED PHOTOGRAPHY. *To make recommendations and prepare specifications for the construction, installation, operation, and servicing of equipment for photographing and projecting pictures taken at high repetition rates or with extremely short exposure times.* (*File 25*)

J. H. Waddell, *Chairman*. Wollensak Optical Co., 850 Hudson Ave., Rochester 5, N.Y.

H. E. Edgerton, *Vice-Chairman*, Dept. of Electrical Engineering, Massachusetts Institute of Technology, Cambridge 39, Mass.

E. A. Andres, Sr.
K. M. Baird
D. M. Beard
H. W. Crouch
C. H. Elmer
R. E. Farnham
W. R. Fraser
W. H. Fritz
Eleanor Gerlach
C. C. Herring
H. M. Lester
L. R. Martin
C. D. Miller
A. P. Neyhart
W. S. Nivison
Brian O'Brien
D. H. Peterson
Earl Quinn
M. L. Sandell
Kenneth Shaftan
C. W. Wyckoff
A. M. Zarem

LABORATORY PRACTICE. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture printers, processing machines, inspection projectors, splicing machines, film-cleaning and treating equipment, rewinding equipment, any type of film-handling accessories, methods, and processes which offer increased efficiency and improvements in the photographic quality of the final print.* (*File 30*)

J. G. Stott, *Chairman*, Du Art Film Laboratories, 245 West 55 St., New York, N.Y.

V. D. Armstrong	I. M. Ewig	O. W. Murray	V. C. Shaner
H. L. Baumbach	T. M. Ingman	W. F. Offenhauser, Jr.	J. H. Spray
D. P. Boyle	P. A. Kaufman	W. E. Pohl	Lloyd Thompson
O. E. Cantor	C. F. LoBalbo	E. H. Reichard	Paul Zeff
Gordon Chambers	J. A. Maurer		

MOTION PICTURE STUDIO LIGHTING. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of all types of studio and outdoor auxiliary lighting equipment, tungsten light and carbon-arc sources, lighting-effect devices, diffusers, special light screens, etc., to increase the general engineering knowledge of the art.* (*File 35*)

M. A. Hankins, *Chairman*, Mole-Richardson Co., 937 N. Sycamore Ave., Hollywood 38, Calif.

Richard Blount	Karl Freund	C. R. Long	D. W. Prideaux
J. W. Boyle	C. W. Handley	W. W. Lozier	Petro Vlahos

OPTICS. *To make recommendations and prepare specifications on all subjects connected with lenses and their properties.* (*File 40*)

R. Kingslake, *Chairman*, Eastman Kodak Co., Hawk Eye Works, Rochester 4, N.Y.

F. G. Back	J. W. Gillon	G. A. Mitchell	L. T. Sachtleben
A. A. Cook	Grover Laube	A. E. Murray	O. H. Schade
C. R. Daily	J. A. Maurer	W. E. Pohl	M. G. Townsley
I. C. Gardner			

PRESERVATION OF FILM. *To make recommendations and prepare specifications on methods of treating and storage of motion picture film for active, archival, and permanent record purposes, so far as can be prepared within both the economic and historical value of the films.* (*File 45*)

J. W. Cummings, *Chairman*, National Archives, Washington 25, D.C.

Henry Anderson	C. R. Fordyce	A. C. Hutton	W. E. Pohl
W. G. Brennan	J. E. Gibson	J. B. McCullough	W. D. Stump
J. W. Dunham	G. Graham	N. F. Oakley	

PROCESS PHOTOGRAPHY. *To make recommendations and prepare specifications on motion picture optical printers, process projectors (background process), matte processes, special process lighting technique, special processing machines, miniature-set requirements, special-effects devices, and the like, that will lead to improvement in this phase of the production art.* (*File 50*)

M. H. Chamberlin, *Chairman*, Metro-Goldwyn-Mayer Studios, Culver City, Calif.

(Under Organization)

SCREEN BRIGHTNESS. *To make recommendations, prepare specifications, and test methods for determining and standardizing the brightness of the motion picture screen image at various parts of the screen, and for special means or devices in the projection room adapted to the control or improvement of screen brightness.* (*File 55*)

W. W. Lozier, *Chairman*, National Carbon Div., Fostoria, Ohio

Herbert Barnett	L. D. Grignon	L. J. Patton	C. R. Underhill, Jr.
F. E. Carlson	A. J. Hatch, Jr.	J. W. Servies	H. E. White
Gordon Edwards	L. B. Isaac	B. A. Silard	A. T. Williams
E. R. Geib	F. J. Kolb	Allen Stimson	D. L. Williams
L. T. Goldsmith	W. F. Little		

16-MM AND 8-MM MOTION PICTURES. *To make recommendations and prepare specifications for 16-mm and 8-mm cameras, 16-mm sound recorders and sound-recording practices, 16-mm and 8-mm printers and other film laboratory equipment and practices, 16-mm and 8-mm projectors, splicing machines, screen dimensions and placement, loudspeaker output and placement, preview or theater arrangements, test films, and the like, which will improve the quality of 16-mm and 8-mm motion pictures.* (*File 60*)

H. J. Hood, *Chairman*, Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

H. W. Bauman	G. A. Del Valle	D. F. Lyman	A. G. Petrasek
W. C. Bowen	J. W. Evans	W. C. Miller	A. C. Robertson
F. L. Brethauer	C. R. Fordyce	J. R. Montgomery	L. T. Sachtleben
F. E. Brooker	John Forrest	J. W. Moore	H. H. Strong
F. E. Carlson	R. C. Holslag	W. H. Offenhauser, Jr.	Lloyd Thompson
S. L. Chertok	Rudolf Kingslake		M. G. Townsley
E. W. D'Arcy	W. W. Lozier		

SOUND. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture film, sound recorders, re-recorders, and reproducing equipment, methods of recording sound, sound-film processing, and the like, to obtain means of standardizing procedures that will result in the production of better uniform quality sound in the theater.* (*File 65*)

L. T. Goldsmith, *Chairman*, Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

G. L. Dimmick, *Vice-Chairman*, RCA Victor Division, Camden, N.J.

F. G. Albin	R. M. Fraser	E. W. Kellogg	G. E. Sawyer
A. C. Blaney	J. G. Frayne	J. P. Livadary	R. R. Scoville
D. J. Bloomberg	L. D. Grignon	K. M. MacIlvain	W. L. Thayer
F. E. Cahill, Jr.	Robert Herr	W. C. Miller	M. G. Townsley
E. W. D'Arcy	J. K. Hilliard	G. C. Misener	R. T. Van Niman
R. J. Engler	L. B. Isaac	Otto Sandvik	D. R. White

STANDARDS. *To survey constantly all engineering phases of motion picture production, distribution, and exhibition, to make recommendations and prepare specifications that may become proposals for American Standards. This Committee should follow carefully the work of all other committees on engineering and may request any committee to investigate and prepare a report on the phase of motion picture engineering to which it is assigned.* (*File 70*)

F. E. Carlson, *Chairman*, General Electric Company, Nela Park, Cleveland 12, Ohio

Chairmen of Engineering Committees

Richard Blount	L. W. Davee	M. A. Hankins	F. J. Pfeiff
E. K. Carver	H. H. Duerr	H. J. Hood	Leonard Satz
M. H. Chamberlin	E. C. Fritts	D. E. Hyndman	J. G. Stott
C. G. Clarke	R. L. Garman	Rudolf Kingslake	J. H. Waddell
J. W. Cummings	L. T. Goldsmith	W. W. Lozier	

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L. A. Jones	J. A. Maurer		

JOINT RTMA-SMPTE COMMITTEE ON TELEVISION FILM EQUIPMENT. *To make recommendations and prepare specifications on all phases of film equipment as used in the television broadcast stations.* (*File 75*)

F. N. Gillette, *RTMA*, *Chairman*, General Precision Laboratory, 63 Bedford Road, Pleasantville, N.Y.

E. C. Fritts, *SMPTE*, *Vice-Chairman*, Eastman Kodak Co., 333 State St., Rochester 4, N.Y.

A. J. Baracket	L. C. Downes	R. M. Morris	C. L. Townsend
Pierre Boucheron	J. A. Maurer	N. F. Oakley	M. G. Townsley
P. F. Brown	H. C. Milholland	R. C. Rheineck	H. E. White
Sydney Cramer	G. C. Misener	J. H. Roe	

FILMS FOR TELEVISION. *To make recommendations and prepare specifications on all phases of the production, processing and use of film made for transmission over a television system excluding video transcriptions.* (*File 80*)

R. L. Garman, *Chairman*, General Precision Laboratories, Inc., 63 Bedford Road, Pleasantville, N.Y.

M. R. Boyer	H. R. Lipman	R. M. Morris	C. L. Townsend
R. O. Drew	G. C. Misener	R. C. Rheineck	L. F. Transue
Richard Hodgson	Pierre Mertz	H. J. Schlafly	T. G. Veal
R. Johnston	H. C. Milholland	N. L. Simmons	H. E. White

TELEVISION STUDIO LIGHTING. *To make recommendations and prepare specifications on all phases of lighting employed in television studios.* (*File 85*)

Richard Blount, *Chairman*, General Electric Co., Nela Park, Cleveland 12, Ohio

H. R. Bell	H. M. Gurin	Robert Morris	W. F. Rockar
A. H. Brolly	Eric Herud	R. S. O'Brien	R. L. Zahour

THEATER TELEVISION. *To make recommendations and prepare specifications for the construction, installation, operation, maintenance, and servicing of equipment for projecting television pictures in the motion picture theater, as well as projection-room arrangements necessary for such equipment, and such picture-dimensional and screen-characteristic matters as may be involved in high-quality theater-television presentations.* (*File 90*)

D. E. Hyndman, *Chairman*, Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

Ralph Austrian	T. T. Goldsmith, Jr.	Nathan Levinson	L. L. Ryder
G. L. Beers	Nate Halpern	W. W. Lozier	Otto Sandvik
F. E. Cahill, Jr.	Richard Hodgson	G. P. Mann	Ed Schmidt
James Frank, Jr.	C. F. Horstman	R. H. McCullough	A. G. Smith
R. L. Garman	L. B. Isaac	F. R. Norton	E. I. Sponable
E. P. Genock	A. G. Jensen	Harry Rubin	J. E. Volkmann
A. N. Goldsmith	P. J. Larsen		

TEST FILM QUALITY. *To develop and keep up to date all test film specifications, and to supervise, inspect and approve methods of production and quality control of all test films sold by the Society.* (*File 95*)

F. J. Pfeiff, *Chairman*, Altec Service Corp., 250 W. 57 St., New York 19, N.Y.

R. M. Corbin	Gordon Edwards	Joseph Spray	M. G. Townsley
Russell Drew	J. A. Maurer	J. G. Stott	

THEATER ENGINEERING. *To make recommendations and prepare specifications of engineering methods and equipment of motion picture theaters in relation to their contribution to the physical comfort and safety of patrons, so far as can be enhanced by correct theater design, construction, and operation of equipment.* (*File 100*)

Leonard Satz, *Chairman*, Raytone Screen Co., 165 Clermont Ave., Brooklyn 5, N.Y.

F. W. Alexa	Charles Bachman	James Frank, Jr.	Ben Schlanger
Henry Anderson	E. J. Content	Aaron Nadell	Seymour Seider
O. P. Beckwith	C. M. Cutler	E. H. Perkins	Emil Wandelmaier

Changes of great importance to you and to your company are now taking place and the program schedule for Lake Placid will be a turning point for many, so plan to take an active part in the 68th Convention.

COLOR

The Color Committee Report "Principles of Color Sensitometry" that appeared first in the June *Journal* has been reprinted and has been acknowledged as the basic text in the rapidly expanding area of color motion pictures.

Research workers, laboratory technicians and students will get a substantial grounding in the theory, the tools and the techniques of color control. Study it yourself, and supply your associates with copies.

Attractive reprints of this 72-page report and bibliography are now available at $1, or at a lower price for quantities of 100 or more.

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- Twentieth Century-Fox Film Corporation
- Warner Brothers Pictures

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Neumade Products Corp.
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Projection Optics Co., Inc.
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Reeves Sound Studios, Inc.
SRT Television Studios
Technicolor Motion Picture Corp.
Terrytoons, Inc.
Theatre Holding Corp., Ltd.
Titra Film Laboratories, Inc.
United Amusement Corp., Ltd.
Universal Pictures Co.
Westinghouse Electric Corp.
Westrex Corp.
Wilding Picture Productions, Inc.